Subject No 12 Aircraft Technical Knowledge (Aeroplane)

Note: This syllabus is primarily based on a single piston-engine GA-type aeroplane.

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. These reference numbers are common across the subject levels and therefore may not be consecutive.

Sub Topic	Syllabus Item
12.1	**Definitions and Units - Basic**
12.1.1	State the International System (SI) and ICAO units used to express: (a) distance; (b) time; (c) velocity; (d) mass; (e) volume; (f) temperature; (g) altitude.
12.1.2	Define and show the relevant relationships: (a) mass, weight, gravitational force (g) and inertia; (b) momentum; (c) force, force vectors, couples and components; (d) equilibrium; (e) Newton's Third Law; (f) distance, time, acceleration and velocity; (g) kinetic and potential energy, work and power; (h) forces involved in the motion of an object travelling in a circular path.
12.4	**The Atmosphere - Basic**
12.4.1	List the principal gases which constitute the atmosphere.
12.4.2	Define air density, and explain how it varies with altitude within the

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	atmosphere.
12.4.3	State the relationship between pressure/temperature and the density of an air mass.
12.4.4	Outline how pressure, temperature and density normally vary in the atmosphere.
12.4.5	Outline the basis for the International Standard Atmosphere (ISA), and state the standard sea level pressure and temperature conditions, together with their lapse rates up to the tropopause.
12.7	**Electricity and Magnetism**
12.7.1	Describe the earth's magnetic field, and: (a) distinguish between the true and magnetic poles; (b) define magnetic variation, isogonals, and deviation.
12.14	**Basic Aerodynamic Theory**
12.14.1	Describe what an aerofoil is and distinguish between different aerofoil designs.
12.14.2	Define: (a) leading edge; (b) trailing edge; (c) chord; (d) thickness; (e) camber.
12.14.3	Define relative airflow and angle of attack.
12.14.4	Explain Bernoulli's Theorem in simple terms.
12.14.5	Describe streamline airflow around an aerofoil, and explain the changes which occur to dynamic and static pressure wherever the speed of the airflow is:

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	(a) increased;
	(b) decreased.
12.14.6	With the aid of diagrams, explain:
	(a) venturi effect;
	(b) the pressure distribution around an aerofoil which is producing lift.
12.14.7	Define the terms; Total Reaction (TR) and Centre of Pressure (CP), and describe how TR and CP change with increasing angle of attack.
12.14.8	Define the Lift and Drag components of Total Reaction.
12.14.9	Summarise the factors affecting lift.
12.14.10	Define the coefficient of lift (CL) and:
	(a) describe a typical CL versus angle of attack curve;
	(b) show how CL varies with use of flaps and control surfaces.
12.14.11	Describe the effects of flying with ice, frost, other contamination or damage to lifting surfaces.
12.14.12	Define and distinguish between induced drag and parasite (other) drag.
12.14.13	Define the factors affecting skin friction, form, and interference drag.
12.14.14	Interpret a curve of parasite drag versus airspeed.
12.14.15	Explain the cause of induced drag, and identify a curve of induced drag versus airspeed (and angle of attack).
12.14.16	Show how, by combining the induced and parasite drag curves, a curve for total drag versus airspeed (and angle of attack) is produced. Identify on this curve, the speed for minimum drag (and maximum L/D ratio).
12.14.17	Interpret a curve of lift/drag (CL/CD) versus angle of attack.
12.15	**Basic Flying Controls**

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12.15.1	Define and name the three aircraft axes of rotation, and define pitch, roll and yaw.
12.15.2	Name the flying controls used to affect movement about each axis, and explain how each control operates to achieve control of the pitch attitude, bank angle, and yaw.
12.15.3	Explain the cross-coupling (further) effects of control in roll and yaw.
12.15.4	Explain the effects of airspeed and power settings on control effectiveness and aircraft attitude.
12.15.5	Explain the purpose and principle of operation of a basic trim control, and state the correct method of use.
12.15.6	Explain the requirement for balancing the controls and state the methods used to obtain aerodynamic balance.
12.15.7	Explain the requirement for using anti-balance tabs on an all-moving tailplane, and describe the principle of operation.
12.15.8	Explain the purpose and the principle of operation of wing flaps.
12.16	**Straight and Level Flight**
12.16.1	Define the four main forces acting in flight, and describe, for level flight, how these forces change as IAS is varied.
12.16.2	Describe the pitching moments in flight, and how longitudinal stability is achieved.
12.16.3	Given a basic graph of power available (PA) and power required (PR) versus TAS in level flight, show the derivation of: (a) maximum and minimum level flight speed; (b) maximum-range speed; (c) maximum endurance speed.
12.16.4	Explain the basic operational considerations which apply to flying an aeroplane for range, or endurance.

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12.17	**Climbing Flight**
12.17.1	Using a diagram, show and name the forces acting in a steady climb.
12.17.2	Distinguish between a maximum angle climb; a maximum rate climb; and a normal climb. Define the meaning of Vx (max angle) and Vy (max rate).
12.17.3	Using a PA/PR (power available/power required) graph, show the derivation of maximum rate of climb speed.
12.17.4	Briefly explain the factors which affect climb performance.
12.18	**Descending Flight**
12.18.1	Using a diagram, show and name the forces acting in a steady glide. Show how the forces in this diagram become modified in a steady-speed power on descent.
12.18.2	Demonstrate how the lift/drag ratio determines the steady-speed glide angle.
12.18.3	Briefly explain the effects of weight, IAS, wind, and flap extension on the glide angle.
12.19	**Turning Flight**
12.19.1	Define centripetal force.
12.19.2	Using a diagram, explain the components of lift which provide the: (a) turning force; (b) force required opposing weight.
12.19.3	Define load factor “g”. In a level turn, state the relationship between bank angle and lift, drag, and load factor.
12.19.4	State the relationship between the turn radius and rate of turn: (a) at a given airspeed; (b) at a given bank angle.

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12.19.5	Describe a rate 1 turn, and a rule-of–thumb method of calculating the bank angle required.
12.19.6	Explain the effect of bank on rate of climb in a climbing turn, and the tendency to “overbank”.
12.19.7	Explain the effect of bank on rate of descent in a descending turn, and the tendency to “underbank”.
12.20	**Stalling and Spinning**
12.20.1	Describe the stalling angle of attack, with reference to: (a) disruption of streamline flow over the upper surface of the aerofoil; (b) reduction of lift and increase in drag.
12.20.2	Describe the symptoms of a developing stall.
12.20.3	Explain how: (a) the stall is associated with a particular angle of attack and not a particular airspeed; (b) a reduction in angle of attack is critical to recovery.
12.20.4	Explain how the stalling IAS is affected by: (a) load factor; (b) aircraft weight; (c) altitude; (d) power; (e) flap extension; (f) damage, ice, frost, or other contamination of the wings.
12.20.5	State the possible consequences of using ailerons near, during and in the recovery from a stall.
12.20.6	Define the term autorotation and the conditions leading to it.
12.20.7	Define a spin, with reference to:

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	(a) stalled condition of flight;
	(b) simultaneous motion about three axes (rolling, pitching, yawing);
	(c) high rate of descent at low airspeed;
	(d) the difference between a spin and a spiral dive.
12.20.8	State what actions can be taken to avoid a spin.
12.20.9	Explain the 'standard' recovery action from a developed spin.
12.24	**Performance Factors**
12.24.1	Describe the general effects of altitude on aircraft performance.
12.24.2	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.
12.24.3	Explain the general effect of temperature on performance.
12.24.4	Define density altitude and, given pressure altitude:
	(a) calculate the deviation of ambient temperature from ISA;
	(b) calculate the density altitude.
12.24.5	Explain the effect of the following factors on TODR and LDR;
	(a) aircraft weight;
	(b) temperature and pressure (i.e. density altitude);
	(c) humidity;
	(d) runway slope;
	(e) runway surface and condition;
	(f) headwind/tailwind component;
	(g) use/misuse of flaps, and power;
	(h) frost or other contaminants/damage of lifting surfaces.

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12.24.6	Describe the hazards of a windshear in the initial climb-out path, and on the approach path.
12.25	**Take-off Performance**
12.25.1	Demonstrate the practical use of Performance charts to determine TODR.
12.25.2	Define the following: (a) take-off distance required (TODR); (b) take-off distance available (TODA);
12.27	**Landing Performance**
12.27.1	Demonstrate the practical use of Performance charts to determine LDR.
12.27.2	Define the following: (a) landing distance required (LDR); (b) landing distance available (LDA).
12.28	**Weight and Balance**
12.28.1	Explain the reasons for operating with correct loading.
12.28.2	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; (f) moment arm.
12.28.3	Explain the effect on stability and control of an aircraft if flown with the CG: (a) ahead of the forward limit;

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	(b) behind the aft limit.
12.28.4	Define the meaning of:
	(a) aircraft datum;
	(b) positive and negative moments (about the datum);
	(c) aircraft station (STA).
12.28.5	Given a basic aircraft load sheet/data, demonstrate ability to:
	(a) calculate the CG position;
	(b) use a typical loading graph to determine CG position;
	(c) use index units.
12.31	**Airframe Structure**
12.31.1	Identify and explain the basic function of the major components of a conventional airframe.
12.31.2	Explain the components and distribution of the load on a wing;
	(a) on the ground,
	(b) in the air, and state the function of spars and struts in opposing these loads.
12.31.3	Describe the precautions required to preserve the structural integrity, and the indications of damage or failure of airframes constructed of;
	(a) aluminium;
	(b) composite;
	(c) fabric covered airframes.
12.31.4	Describe the procedure for tie down (or picketing) a light aircraft.
12.32	**Control systems**
12.32.1	Explain the common methods of the mechanical operation of the primary flight controls, trim tab and flap systems.

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12.32.2	Describe the function of control locks and precautions for removal before flight.
12.32.3	Describe the normal operational use of flaps, including limitations.
12.34	**Engines – General Piston Engines**
12.34.1	Identify typical cylinder configurations used for aircraft piston engines.
12.34.2	Compare the basic differences between compression ignition (diesel) engines and conventional ignition engines.
12.34.3	Identify and describe the purpose of the major components of a four-stroke piston engine (cylinders, pistons, connecting rods, crankshaft, crankcase, camshaft, valves, spark plugs and injectors).
12.34.4	With the aid of diagrams, explain the basic principle of operation of a four stroke internal combustion engine.
12.34.5	Describe the correlation between engine rpm and power output.
12.38	**Carburation**
12.38.1	Explain the principle of carburation.
12.38.2	With the aid of a diagram, explain the operating principle of a simple float-type carburettor.
12.38.3	Describe the purpose of the following within the carburettor; (a) atomization and diffusion; (b) enrichment at high power settings.
12.38.4	Explain the function and correct operational use of a manual mixture control and idle cut-off.
12.38.5	Describe the effects of excessively rich or lean mixtures on engine operation.
12.38.6	Describe the abnormal combustion conditions of detonation and pre-ignition, and distinguish between them.

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12.38.7	Explain the causes and likely effects of detonation and pre-ignition and the measures which can be taken to avoid them.
12.38.8	Explain the formation of refrigeration, throttle and impact ice in a carburettor and intake system.
12.38.9	Describe 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.
12.38.10	Describe the function of the inlet and exhaust manifold.
12.39	**Fuel injection**
12.39.1	Explain; (a) the function and principles of a fuel injection system; (b) the difference between direct and indirect injection.
12.39.2	With the aid of a diagram, explain the operating principle of a simple fuel injection system.
12.39.3	State the purpose of the following components in a basic fuel injection system: (a) fuel delivery pump system; (b) fuel distribution system; (c) fuel injectors.
12.41	**Exhaust System**
12.41.1	Describe the possible sources, indications and associated danger of carbon monoxide gas.
12.42	**Engine Management - Piston**

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12.42.1	State the safety precautions to be taken before starting the engine.
12.42.2	In general terms, explain the procedures for: (a) starting the engine in cold temperatures; (b) starting an over-primed engine; (c) starting a hot engine; (d) controlling an engine fire on start-up; (e) checking oil pressure after start; (f) stopping the engine.
12.42.3	Explain the reasons for avoidance of rapid power changes, and the need for monitoring and cross-checking engine instrument indications.
12.42.4	State the possible causes for rough running or excessive engine vibration and the actions that the pilot may take to identify and rectify the problem.
12.42.5	State the possible causes of a sudden engine failure in flight, and the remedies which may be available to a pilot during subsequent trouble checks.
12.43	**Ignition Systems - Magnetos**
12.43.1	Describe the principal features of a typical magneto ignition system (dual, independent, engine-driven magneto systems with two spark plugs per cylinder).
12.43.2	State the purpose and principle of an impulse coupling.
12.43.3	Describe the operation and correct handling of a rotary ignition/starter switch (including the starter warning light), and separate toggle ignition switches.
12.43.4	Explain the purpose and a typical procedure for conducting magneto checks.
12.43.5	Describe the procedures and the precautions to be taken when hand-swinging a propeller to start an engine.

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12.44	**Ignition Systems – Solid State**
12.44.1	Describe the principal features and components of a typical solid state ignition system.
12.44.2	Describe the operation and correct handling of ignition/starter switch systems.
12.44.3	Explain the purpose and a typical procedure for conducting ignition integrity checks.
12.44.4	Explain the advantages/disadvantages of solid state ignition systems.
12.46	**Propellers**
12.46.1	With respect to propeller terminology, define the meaning of the following: (a) blade section; (b) blade angle; (c) helix (or pitch) angle; (d) angle of attack.
12.46.2	Explain the reason for blade (or helical) twist.
12.46.3	With the aid of a diagram, identify and define the following (for a rotating blade section): (a) direction of rotation; (b) relative airflow; (c) total reaction, with its components; (d) thrust and propeller torque.
12.46.4	For a fixed-pitch propeller at a constant throttle setting, explain the relationship between airspeed, angle of attack and rpm.
12.46.5	Briefly explain the factors which affect the ability of a fixed-pitch propeller to convert engine power into useful thrust.
12.46.6	Explain the basic principle of operation for a constant-speed propeller, and the normal procedure for changing power settings with the manifold

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	pressure and pitch controls.
12.46.7	State the principal advantage of a constant-speed versus a fixed-pitch propeller.
12.46.8	Describe the function and operation of a typical reduction gearbox.
12.52	**Electrical System - DC**
12.52.1	Describe the types of systems which are typically electrically operated in a light aircraft.
12.52.2	Explain the function of the following components in a typical light aircraft electrical system: (a) battery; (b) alternator and generator; (c) bus bar; (d) voltage regulator, voltmeter or over voltage light; (e) ammeter; (f) master switch and battery/alternator switches; (g) fuses and circuit breakers.
12.52.3	Explain the precautions to take during normal operation of the electrical system, including: (a) avoiding continuous operation of high-power systems on the ground before 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.

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12.52.4	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.
12.55	**Landing Gear - Fixed**
12.55.1	State the two common types of undercarriage system (tricycle/tail wheel) and explain typical steering and braking systems with precautions for use in each type.
12.60	**Fuel**
12.60.1	State the common types of fuels and their colour identification.
12.60.2	Distinguish between the different characteristics of AVGAS, MOGAS and AVTUR, and state the precautions regarding the use of MOGAS in aero-engines.
12.60.3	State the common fuel contaminants and the precautions which can be taken to avoid them.
12.61	**Fuel Pumps**
12.61.1	Describe the function of the following components of a simple fuel system: (a) fuel selector valve, supply line, strainer and strainer drain; (b) fuel primer, engine-driven pump, auxiliary (boost) pumps.
12.61.2	Describe the correct management of the fuel system, including fuel selection and handling of priming and auxiliary pumps.
12.62	**Fuel Tanks**
12.62.1	Describe the function of the following components of a simple fuel system: (a) fuel tank, sump, drain point, supply line standpipe, vents, overflow drain;

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	(b) fuel quantity indicators;
	(c) fuel tank construction and associated limitations.
12.62.2	Describe the procedure to be used for a fuel drain check.
12.62.3	State the general rules for fuelling of aircraft, including the special precautions for the use of drum stock, and plastic containers.
12.62.4	Explain the importance of aircraft earthing during refueling.
12.64	**Cooling Systems - Engines**
12.64.1	Describe the principle components of aircraft engine air and liquid cooling systems.
12.64.2	Explain the precautions to be taken to prevent overheating and overcooling in flight, and explain the correct handling of engine cowl flaps when fitted.
12.66	**Lubrication Systems - Engines**
12.66.1	Identify the functions of engine oil.
12.66.2	Explain the term viscosity and the effect of temperature on the lubricating qualities of oil.
12.66.3	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 and filters;
	(f) oil pressure and temperature gauges.
12.66.4	Explain the importance of using the correct type and grade of oil for a particular aircraft, and of checking the correct oil quantity before flight.
12.66.5	Identify cockpit indications of a possible oil system malfunction, and

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	describe the pilot actions that the pilot can take to rectify the problem.
12.66.6	Describe the correct oil replenishment procedure for a typical light aircraft.
12.74	**Pressure Instruments**
12.74.1	Identify the three basic instruments which rely on air pressure for their operation.
12.74.2	Describe static pressure and dynamic pressure, and the main factors which affect them.
12.74.3	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, and pitot cover; (e) alternate pressure source.
12.74.4	With respect to the airspeed indicator, describe the: (a) basic principle of operation and serviceability checks; (b) colour coding, and the meaning of VSO, VS1, VFE, VNO and VNE; (c) IAS/TAS/groundspeed relationship; (d) errors affecting the ASI, and how position error correction is applied.
12.74.5	With respect to the altimeter, describe the: (a) basic principle of operation and serviceability checks; (b) subscale settings and the meaning of QNH and QFE; (c) errors affecting the altimeter, including subscale setting error.
12.74.6	With respect to the vertical speed indicator, describe the: (a) basic principle of operation; (b) errors affecting the VSI.

Sub Topic	Syllabus Item
12.74.7	Indicate the normal checks for serviceability of the pitot-static system, both pre-flight and during operation.
12.74.8	Identify the cockpit indications of the following pitot-static system malfunctions, and state the actions available to the pilot to deal with the problem: (a) blockage of the pitot tube; (b) blockage of the static source.
12.75	**"EFIS" Instrument Displays**
12.75.1	Describe the function and operation of a typical EFIS cockpit display system.
12.75.2	Describe the function of the: (a) air data computer; (b) signal generator; (c) input data sources to a typical basic EFIS flight display system.
12.75.3	Describe the function and operation of a typical basic Attitude Heading Reference.
12.76	**Magnetic Instruments**
12.76.1	Given a sample deviation card, show how to apply corrections.
12.76.2	Briefly describe the construction of a modern direct-reading compass, and (a) define lubber line; (b) state the functions of the fluid in the bowl.
12.76.3	Explain magnetic dip; how it is compensated for; and define residual dip.
12.76.4	State the effects of: (a) acceleration error; (b) turning error.

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12.76.5	State the compass pre-flight serviceability checks, and the precautions when carrying magnetic items.
12.77	**Gyroscopic Instruments**
12.77.1	Outline the basic principle of operation of the vacuum system, and state the likely effects of reduced or nil suction.
12.77.2	Describe the basic gyroscopic properties of rigidity and precession.
12.77.3	With respect to the turn indicator/coordinator: (a) with the aid of a diagram, differentiate between the different indications of the turn indicator and turn coordinator; (b) state the function, indication and correct use of the coordination (balance) ball; (c) state the pilot checks for serviceability.
12.77.4	With respect to the heading indicator (or DGI), explain the: (a) advantages of a gyroscopic heading indicator (versus a compass); (b) need for, and method of synchronisation; (c) pilot checks for serviceability.
12.77.5	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; (d) the need for, and operation of, a caging device.
12.77.6	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.
12.79	**GNSS Instruments**
12.79.1	Describe the basic principles and operation of a Global Navigation Satellite

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	System (GNSS).
12.79.2	Describe the limitations and failure indications of a Global Navigation Satellite System (GNSS).
12.80	**ELT Systems**
12.80.1	Describe the function and operation of an aircraft ELT system.