Subject No 28 General Aircraft Technical Knowledge (Helicopter)

Note: This syllabus is generally based on a light piston-engine 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.

Sub Topic	Syllabus Item
28.2	**Engines**
28.2.2	State the basic difference between reciprocating (piston) and gas turbine (jet) engines.
28.2.4	Distinguish between the basic types of piston aircraft engine.
28.2.6	State the fundamental operating principle of the reciprocating (piston) engine.
28.2.8	Identify the main components of a four-stroke cycle piston engine including:
	(a) cylinders;
	(b) pistons;
	(c) cylinder heads;
	(d) valves;
	(e) spark plugs;
	(f) connecting rods;
	(g) crankshaft;
	(h) camshaft;
	(i) valve operating mechanism.
28.2.10	With respect to a four-stroke piston engine, explain the meaning of the following terms:
	(a) cycle;
	(b) stroke;
	(c) top dead centre (TDC);
	(d) bottom dead centre (BDC);
	(e) bore;
	(f) clearance volume;
	(g) swept volume;
	(h) compression ratio;
	(i) firing interval;
	(j) firing order;

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	(k)	manifolds;
	(l)	manifold pressure;
	(m)	crank angle.
28.2.12	Explain the operation of the four-stroke cycle.	
28.2.14	Explain valve lag, valve lead, valve overlap, and the advantages of valve overlap.	
28.2.16	Explain the meaning of the term ‘ignition timing’ and the need for spark advance.	
28.2.18	Distinguish between detonation and pre-ignition, state the main causes of these conditions, and the reasons for avoiding them.	
28.4	**Engine Performance**	
28.4.2	Explain the meaning of the terms:	
	(a)	force;
	(b)	work;
	(c)	power;
	(d)	energy;
	(e)	engine torque.
28.4.4	Explain the relationship between horsepower and kilowatts.	
28.4.6	Explain the meaning of:	
	(a)	brake power;
	(b)	rated power;
	(c)	rated altitude or critical altitude;
	(d)	full throttle height.
28.4.8	Explain the meaning of:	
	(a)	thermal efficiency;
	(b)	mechanical efficiency;
	(c)	volumetric efficiency.
28.4.10	Explain the relationship between typical brake power and power available curves.	
28.4.12	Explain the general conditions for the most efficient engine operation.	
28.4.14	Describe the effect of changing altitude on manifold pressure and power output of normally aspirated engines.	
28.6	**Carburation & Fuel Injection**	

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28.6.2	Describe the operation of a float type carburettor.
28.6.4	Explain the following in relation to fuel-air mixture ratios:
	(a) 'rich' and 'lean';
	(b) normal workable mixture ratio limits;
	(c) the 'chemically correct' or 'stoichiometric' ratio;
	(d) the approximate ratios for maximum power output and best economy.
28.6.6	Describe a typical carburettor mixture setting curve and show the operating area where detonation will occur.
28.6.8	Explain the basic principle of operation of a simple float-type carburettor.
28.6.10	Explain the need for the following in an aero-engine carburettor:
	(a) a venturi;
	(b) atomisation and diffusion;
	(c) an accelerating system;
	(d) an idling system;
	(e) a power enrichment (economiser) system;
	(f) a mixture control;
	(g) a cut-off system.
28.6.12	State the two main disadvantages with use of a float-type carburettor in an aero-engine.
28.6.14	State the principal difference between a fuel injection system and carburetted systems.
28.6.16	Explain the principal differences between continuous flow fuel injection, and direct fuel injection systems.
28.6.18	Explain the advantages and disadvantages of using fuel injection systems in aero-engines.
28.6.20	State the correct use of the mixture control.
28.6.22	Explain the consequences of operating with over-rich and over-lean mixture settings.
28.6.24	With respect to carburettor ice, explain the process and atmospheric conditions for the formation of:
	(a) refrigeration (or fuel) ice;
	(b) throttle ice;
	(c) impact ice.
28.6.26	Explain the normal symptoms of carburettor ice formation, and the correct use of the

Sub Topic	Syllabus Item
	carburettor heat control.
28.6.28	Describe the effect of carburettor icing stopping engine operation in a helicopter.
28.6.30	Describe the effect of excessive carburettor heat in high output engines.
28.8	**Induction and Exhaust Systems; and Supercharging**
28.8.2	With respect to carburettor air intakes, explain the correct use of: (a) ram air; (b) the filter; (c) carburettor heat.
28.8.4	Describe the effects of the partial blockage of the engine air intake filter.
28.8.6	Explain the reasons for a reduction in power when carburettor heat is operated.
28.8.8	In general terms, describe the function of the inlet and exhaust manifold.
28.8.10	Explain the importance of proper sealing of the exhaust manifold.
28.8.12	Explain the advantages, and the limitations of supercharging.
28.8.14	Explain the basic principle of operation of exhaust-driven superchargers (turbochargers).
28.8.16	Describe the flight profiles where the likelihood of carbon monoxide poisoning is increased.
28.10	**Fuel Systems**
28.10.2	Distinguish between gravity-feed and pump-feed fuel systems.
28.10.4	For a simple fuel system, explain the function, and where appropriate, the correct handling of the following: (a) tank filler caps and drains; (b) expansion spaces; (c) tank vents; (d) baffles; (e) sumps and drains; (f) fuel quantity detectors; (g) fuel strainers and filters; (h) tank selector valves; (i) engine-driven fuel pump; (j) boost (auxiliary) pump(s);

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	(k) engine primers and priming systems.
28.10.6	Describe the importance of correct management of fuel selection.
28.10.8	List the actions recommended in the case of loss of power through faulty fuel selection.
28.10.10	State the differences between aviation gasoline (AVGAS) and motor gasoline (MOGAS).
28.10.12	Explain fuel octane ratings and performance numbers.
28.10.14	State the grades of AVGAS available in New Zealand, together with their colours.
28.10.16	Explain the likely result of using a higher grade, or a lower grade, of fuel than that recommended for a given aircraft.
28.10.18	State the caution against using automobile fuel (MOGAS) in an aircraft engine, unless specifically authorised.
28.10.20	Describe the distinguishing features of aviation turbine fuel (AVTUR) and state the difference between the decals used on AVTUR and AVGAS fuelling equipment.
28.10.22	State the precautions which can be taken to avoid fuel contamination with water and other impurities.
28.10.24	State the special precautions which must be taken when fuelling from drum stock, and the avoidance of the use of non-approved plastic containers.
28.10.26	Describe the correct procedures to be used for carrying out a fuel check.
28.10.28	Describe the indications of water in a fuel sample.
28.10.30	Describe the general rules for refuelling an aircraft, and the correct use of fuel tank dipsticks.
28.10.32	Describe the symptoms of a blocked fuel tank vent in a gravity feed fuel system.
28.12	**Ignition Systems**
28.12.2	State the reasons for fitting independent dual ignition systems to engines.
28.12.4	List the essential components of an ignition system.
28.12.6	Describe, in broad terms, the operation of the following:
	(a) an aircraft magneto;
	(b) the distributor;
	(c) ignition harness (high tension leads);
	(d) spark plugs;
	(e) impulse couplings.
28.12.8	Explain the purpose of fitting an “impulse” coupling to a magneto.

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28.12.10	Explain the reason ignition is timed to occur before top dead centre (TDC).
28.12.12	Describe the operation of the ignition switch(es) in the cockpit.
28.12.14	Outline the correct procedures to be followed during magneto checks.
28.12.16	Describe the indications of various problems manifested during a magneto check.
28.12.18	Describe the functioning of the starter motor, and outline the correct operation of the starter switch.
28.12.20	Explain the causes of spark plug fouling and the methods of clearing such fouling.
28.14	**Lubrication and Cooling Systems**
28.14.2	Explain the main functions of the engine oil system.
28.14.4	Describe the effect of temperature on the viscosity and lubrication qualities of oil.
28.14.6	Compare the features of the ashless dispersant (AD) oils used in piston aero-engines with straight mineral oil and detergent oils.
28.14.8	With respect to oil grades, differentiate between the commercial aviation numbers and SAE ratings.
28.14.10	Differentiate between a wet sump and a dry sump oil system.
28.14.12	Describe the function of:
	(a) the engine-driven oil pump and pressure relief valve;
	(b) oil lines, passages and galleries;
	(c) oil sumps and scavenge pumps;
	(d) oil cooler;
	(e) oil tank and filter.
28.14.14	Explain the need for periodic oil changes.
28.14.16	Describe the correct oil replenishment procedure.
28.14.18	Describe the likely results of operating an engine with:
	(a) incorrect oil type;
	(b) incorrect oil quantity.
28.14.20	Describe the likely causes of:
	(a) low oil pressure;
	(b) high oil pressure;
	(c) high oil temperature.
28.14.22	Explain the relationship between a fluctuating or low oil pressure reading

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	accompanied by a rise in oil temperature, and the actions which the pilot should take.
28.14.24	State the reasons why excessively high engine temperatures must be avoided.
28.14.26	Explain the most common means of engine cooling in helicopters fitted with reciprocating engines.
28.14.28	For an air-cooled engine, explain the function of: (a) cowling ducts and baffles; (b) cooling fins.
28.14.30	Explain the method of reducing CHT in a piston engined helicopter.
28.16	**Electricity and Magnetism**
28.16.2	Explain the basis of an electrical current, and the direction of the current.
28.16.4	Describe the basic characteristics of an electrical flow the terms [amps, volts, electro-magnetic force (emf) and ohms].
28.16.6	State Ohm's law.
28.16.8	With the aid of diagrams, describe simple 'two-wire' and 'single wire' grounded electrical circuits.
28.16.10	Distinguish between direct and alternating current, and explain the terms 'Hertz' and 'rectification'.
28.16.12	Describe the properties of magnetism, including polarity, attraction and repulsion.
28.16.14	Distinguish between temporary and permanent magnets, and the properties of 'soft iron' and 'hard iron'.
28.16.16	Describe the terms magnetic field, magnetic flux, and permeability.
28.16.18	Explain 'electromagnetism' and with the aid of diagrams, show the lines of magnetic force around a straight conductor and a coil.
28.16.20	Describe the principle of operation of an electromagnetic switch (or relay) and a solenoid switch, and state typical examples of their use in aircraft electrical circuits.
28.16.22	List the six ways in which an 'emf' can be generated.
28.16.24	Explain the principle of electromagnetic induction.
28.16.26	Describe the principle of operation of a simple alternator (a magnet rotating inside a loop conductor).
28.16.28	Show the features of a practical alternator, and explain how the a.c. output is normally rectified to provide d.c.
28.16.30	Describe the principle of operation of a simple generator (a loop conductor rotating inside a magnet).
28.16.32	Show the features of a practical generator, and explain how the output is passed

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	through a commutator to provide d.c.
28.16.34	Explain the need for voltage regulation for both alternators and generators, and how a generator also requires a current regulator and a reverse current relay.
28.16.36	Explain the principle of operation of a basic electric cell (battery).
28.16.38	Distinguish between primary and secondary cells, wet-cells and dry cells, lead-acid and nickel-cadmium (and similar) types.
28.16.40	Explain the basic features and operation of: (a) a lead-acid battery; (b) a nickel-cadmium (nicad) battery.
28.16.42	Determine the duration of battery operation following a generator failure.
28.18	**Electrical Systems**
28.18.2	State the systems which typically require electrical power in a light helicopter.
28.18.4	Explain the function(s) of the following in a typical helicopter electrical system: (a) the battery; (b) a ground power source; (c) the alternator or generator; (d) bus bar; (e) overvoltage protection.
28.18.6	Describe the advantages and disadvantages of a generator and an alternator.
28.18.8	Distinguish between the functions and interpretation of left-zero and centre-zero ammeters.
28.18.10	Distinguish between the functions and correct operation of a single battery master switch and split battery/alternator switches.
28.18.12	Distinguish between the way in which fuses, circuit breakers and overload switches operate.
28.18.14	Explain airmanship points of handling the electrical system, including: (a) avoiding overheating electrical services if operated during pre-flight; (b) not starting or stopping the engine with unnecessary electrical equipment switched on; (c) avoiding prolonged use of the starter motor; (d) checking satisfactory operation of the alternator/generator after start, and periodically during flight; (e) ensuring the battery master is switched off before vacating the aircraft after

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	flight.
28.18.16	Explain the diagnosis, effect and correct handling of electrical malfunctions including:
	(a) blown fuse/popped circuit breaker;
	(b) an excessive charge rate;
	(c) alternator/generator failure;
	(d) a total electric failure.
28.20	**Engine Instruments**
28.20.2	Describe the function and principle of operation of the following instruments:
	(a) tachometers (rpm) gauges (centrifugal, drag cup, electrical and electronic types);
	(b) manifold pressure and boost gauges;
	(c) oil pressure gauges (direct reading, remote indicating and ratiometer types);
	(d) fuel pressure gauges;
	(e) vacuum gauges;
	(f) cylinder head and exhaust gas temperature (thermocouples);
	(g) oil temperature gauges;
	(h) outside air temperature gauges;
	(i) fuel quantity and fuel flow gauges.
28.20.4	Explain the principle of operation of a simple a.c. synchro system.
28.20.6	Describe the principle of operation and state the purpose of the transmission/engine chip detector warning system.
28.20.8	Explain the requirement for a dual purpose tachometer in a helicopter.
28.20.10	Describe the indications on the engine/rotor tachometer of an autorotation, with and without the engine running.
28.22	**Pressure Instruments**
28.22.2	Define static air pressure, dynamic pressure and total (pitot) pressure.
28.22.4	State the pressure requirements of the three basic pressure instruments.
28.22.6	Describe a simple pitot-static system and distinguish between a single pitot (pressure) head and separate pitot tube and static vents.
28.22.8	State the function of pitot heat.
28.22.10	With the aid of a diagram, describe the principle of operation of an airspeed indicator (ASI).

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28.22.12	State the conventional colour coding of a typical light aircraft ASI.
28.22.14	Explain the following errors affecting an ASI: (a) density error (IAS/TAS relationship); (b) position (pressure) error; (c) compressibility error.
28.22.16	State the pre-flight and in-flight serviceability checks for an ASI.
28.22.18	Explain the principle of operation of an altimeter.
28.22.20	Explain the meanings of the subscale settings QNH, QFE and QNE.
28.22.22	State the effect of pressure setting error on altimeter indication.
28.22.24	State the effect of airmass temperature at constant QNH on altimeter indication.
28.22.26	Explain the following errors affecting an altimeter: (a) instrument error; (b) position error; (c) lag.
28.22.28	State the serviceability checks and the accepted indication tolerances of an altimeter.
28.22.30	Explain the principle of operation of a vertical speed indicator (VSI).
28.22.32	Explain the following errors affecting a VSI: (a) position error; (b) lag.
28.22.34	State the serviceability checks for a VSI.
28.22.36	Explain the symptoms, effects, and possible remedies available, for blockages and leaks in the pitot-static system to each of the pressure instruments.
28.24	**Gyroscopic Instruments**
28.24.2	Describe a typical aircraft vacuum (suction system).
28.24.4	Distinguish between suction pump, venturi, and positive pressure systems.
28.24.6	Describe the inherent properties of a spinning gyroscope rotor.
28.24.8	Explain what is meant by the term gimbal.
28.24.10	List the four types of gyroscope.
28.24.12	Explain the principle of operation of a turn indicator.
28.24.14	Distinguish between a turn indicator (TI) and a turn co-ordinator (TC).

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28.24.16	Describe the errors which a turn indicator is subject to.
28.24.18	State the principle of operation of the balance ball.
28.24.20	With the aid of diagrams, interpret various TI and TC indications.
28.24.22	Explain the serviceability checks for the TI/TC.
28.24.24	Explain the principle of operation of a direction indicator (DI) [or heading indicator (HI)].
28.24.26	Explain the following errors which the DI/HI is subject to: (a) gimbal error; (b) real drift (or real wander); (c) apparent drift (or apparent wander); (d) low rotor speed.
28.24.28	Describe the characteristics of a toppled directional gyro (DI/HI).
28.24.30	State the common operating limitations and serviceability checks for a DI/HI.
28.24.32	State the advantages of an electrically-driven DI/HI versus an air-driven instrument.
28.24.34	With the aid of a diagram, explain the principle of operation of an artificial horizon (AH) [or attitude indicator (AI)].
28.24.36	Briefly describe the effects of a straight-line acceleration and a turn, on the pendulous unit of an air-driven AH/AI, and state the errors in indication arising from these effects.
28.24.38	State the general operating limitations of an air-driven and an electrically-driven AH/AI.
28.24.40	With the aid of diagrams, distinguish between the indications of the TC and AH/AI under various conditions.
28.26	**Compasses**
28.26.2	Describe the features of the earth's magnetic field (flux) and define variation.
28.26.4	Describe the angle of dip and components H and Z of the earth's magnetic flux.
28.26.6	Describe the basic features of a typical aircraft direct-reading magnetic compass, and explain the reason(s) for: (a) pendulous suspension of the magnet system; (b) immersing the magnet system in fluid.
28.26.8	Describe acceleration and turning errors in a direct-reading compass, and the practical aspects of these errors.
28.26.10	Define deviation and state how it is compensated for in a direct-reading compass.

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28.26.12	Given a typical deviation card, apply corrections for residual deviation.
28.26.14	State the serviceability checks for a direct-reading compass.
28.26.16	Explain what a compass swing is and give examples of the occasions on which it is required.
28.28	**Helicopter Airframes**
28.28.2	Explain the effects of the application of a load to an airframe structure (stress and strain) and differentiate between bending, tensile, compression, torsional and shear loads.
28.28.4	State the requirements which the undercarriage/landing skid system must be able to meet.
28.28.6	Describe the features of simple light helicopter undercarriage/landing skid construction.
28.28.8	State the procedure for tie down (or picketing) a light helicopter.
28.30	**Transmission Systems**
28.30.2	State the purpose of a freewheeling unit.
28.30.4	State the purpose of a swashplate assembly.
28.30.6	State the purpose of a centrifugal clutch in a helicopter transmission system.
28.30.8	State the purpose of a rotor brake.
28.30.10	Explain the purpose of the main rotor gear box.
28.30.12	State the purpose and describe the principle of operation of the swashplate (control orbit).
28.30.14	State the most common method of cooling main transmissions.
28.30.16	Explain the procedures and reasons for the laboratory analysis of transmission oil samples.
28.30.18	State the reason for employing chip detectors in the transmission.
28.30.20	Describe the causes and symptoms of high frequency vibrations.
	Rotor Systems
28.32	**Main Rotor Systems**
28.32.2	Describe the construction of modern helicopter rotor blades.
28.32.4	Describe the design features of: (a) rigid rotor systems; (b) semi-rigid rotor systems; (c) fully articulated rotor systems.

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28.32.6	Explain the causes of dragging in a fully articulated rotor system.
28.32.8	Explain the function of the blade damper in fully articulated rotor systems.
28.32.10	Explain the reason a semi-rigid (two-bladed) rotor system is frequently “under-slung”.
28.32.12	Explain the design feature (advance angle) which compensates for phase lag.
28.32.14	Explain the reason for rigging the rotor mast away from the vertical.
28.32.16	Describe the methods of chordwise and spanwise balancing.
28.32.18	Explain the reason for sweepback design near main rotor blade tips.
28.32.20	Explain the reason for washout in the design of main rotor blades.
28.32.22	Explain the advantages of employing a “delta-three hinge” in a fully articulated rotor system.
28.32.24	Explain the purpose of employing an “offset pitch horn” in a rotor system.
28.32.26	Explain the normal methods of trimming controls in a helicopter.
28.32.28	Describe the various methods of rotor stabilisation.
28.32.30	Describe the susceptibility of the various rotor systems to ground resonance.
28.32.32	Describe the susceptibility of the various rotor systems to mast bumping.
28.32.34	Describe the various types of vibration which may occur in a helicopter and explain their causes and possible remedies.
28.32.36	Describe the design feature employed to reduce vibration in semi-rigid rotor systems.
28.34	**Tail Rotor Systems**
28.34.2	Describe the construction of modern tail rotors and their hubs.
28.34.4	State the purpose of a “strike tab” on the tail rotor blades.
28.34.6	Describe the advantages and disadvantages associated with conventional exposed tail rotors.
28.34.8	Explain the advantages and disadvantages associated with shrouded (Fenestron) tail rotors.
28.34.10	Explain the reason asymmetric aerofoils tend to be employed on tail rotors and not on main rotors.
28.34.12	Describe alternate methods of anti-torque control.
28.34.14	Describe the effect a jammed or failed tail rotor.
28.34.16	Describe the design features which can be employed to reduce tail rotor roll.
28.36	**Helicopter Controls**
28.36.2	Describe the purpose and principle of operation of the collective control.

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28.36.4	Describe the purpose of a throttle cam-linkage (correlating unit).
28.36.6	Describe the purpose of the twist grip throttle.
28.36.8	Describe the purpose and principle of operation of the cyclic control.
28.36.10	Describe the purpose and principle of operation of the tail rotor pedal controls.
	Support Systems
28.38	**Hydrodynamics**
28.38.2	State Pascal's principle.
28.38.4	With the aid of diagrams, describe mechanical advantage, and show how it can be gained hydraulically.
28.38.6	Demonstrate the principle of operation of aircraft hydraulic services.
28.40	**Hydraulic Systems**
28.40.2	State the advantages of using hydraulics to operate aircraft services.
28.40.4	Differentiate between the three types of hydraulic oil.
28.40.6	Describe the function of common hydraulic system components; including: (a) reservoirs; (b) pumps; (c) pressure regulators; (d) accumulators; (e) check valves and relief valves; (f) selector valves; (g) actuators; (h) filters.
28.40.8	With the aid of schematic diagrams, describe the operation of the following hydraulic systems: (a) open centre system; and, (b) pressurised system.
28.42	**Pneumatic systems**
28.42.2	Briefly state the advantages and disadvantages of pneumatic systems versus hydraulic systems.
28.42.4	Outline the operation of the following pneumatic systems with the aid of a schematic diagram:

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	(a)	back-up systems;
	(b)	low pressure systems.
28.44	**Fire protection systems**	
28.44.2	Outline the operation of unit-type and continuous loop fire detectors.	
28.44.4	List the common extinguishing agents and state any precautions when using them.	
28.44.6	Describe common fire extinguishing systems and the limitations with their use.	
28.46	**Helicopter Weight and Balance**	
28.46.2	Explain the meaning of the following terms:	
	(a)	arm (moment arm);
	(b)	datum;
	(c)	moment (including units used);
	(d)	centre of gravity (CofG);
	(e)	centre of gravity range and limits;
	(f)	longitudinal centre of gravity (CofG);
	(g)	lateral centre of gravity (CofG);
	(h)	station;
	(i)	index units;
	(j)	basic empty weight (empty aircraft weight);
	(k)	empty weight centre of gravity position;
	(l)	basic operating weight (aircraft prepared for service weight);
	(m)	payload (commercial load);
	(n)	zero fuel weight;
	(o)	ramp weight;
	(p)	gross weight;
	(q)	takeoff weight;
	(r)	maximum certified take-off weight (MCTOW);
	(s)	landing weight;
	(t)	maximum certified landing weight (MCLW);
	(u)	centre of gravity envelope;

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	(v) the specific gravity and the weight of AVGAS.
28.48	**Weight**
28.48.2	Explain the effect of operating a helicopter outside of its weight limits.
28.48.4	Solve the following loading problems:
	(a) calculate the takeoff weight of a helicopter;
	(b) calculate the landing weight of a helicopter;
	(c) calculate the landing weight limited takeoff weight;
	(d) calculate the weight of a given volume of fuel, given the fuel's specific gravity;
	(e) convert between US gallons and litres;
	(f) convert between pounds and kilograms;
	(g) calculate the payload available given a maximum takeoff weight;
	(h) calculate the payload available given a maximum zero fuel weight;
	(i) calculate the allowable load in various compartments.
28.50	**Centre of Gravity**
28.50.2	Explain the principles of helicopter balance.
28.50.4	Explain the effect of operating a helicopter outside of the centre of gravity limits.
28.50.6	Calculate the longitudinal centre of gravity position for a helicopter.
28.50.8	Calculate the lateral centre of gravity position for a helicopter.
28.50.10	Plot a helicopter's longitudinal and lateral centre of gravity position on a graph showing the centre of gravity limits.
28.50.12	Explain the effect of external loads on the centre of gravity position.
28.50.14	Solve the following loading problems:
	(a) loading or offloading weight and find a new CofG position;
	(b) loading or offloading weight to place the CofG at a given station;
	(c) loading or offloading weight at a given station without exceeding CofG limits;
	(d) moving weight from one station to another and finding new CofG position.
28.50.16	Explain the likely effect of fuel burn on the centre of gravity position.
28.50.18	Explain the likely effect of a displaced lateral centre of gravity on the position of the cyclic control.