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**AIC**

7/02
4TH DECEMBER

# PROFESSIONAL PILOT GROUND EXAMINATION – NEW AIRCRAFT TECHNICAL GROUP OF PAPERS AND REVISED SYLLABI

## Introduction

1. This circular is to advise applicants sitting for professional pilot ground examination of the new grouping of the papers in the Aircraft Technical Group of Papers and the revised syllabi effective from 1 March 2003.

## New Aircraft Technical Group of Papers

2. The Aircraft Technical Group of papers has been re-grouped into five papers as follows :

| Existing Aircraft Technical Group of Papers | New Aircraft Technical Group of Papers |
|---|---|
| Theory of Flight (Aeroplanes)<br>Flying Controls (Aeroplanes)<br>Variable Pitch Propellers (Aeroplanes)<br>Theory of Flight (Helicopters)<br>Flying Controls (Helicopters) | [1]Principles of Flight (Aeroplanes) /<br>[2]Principles of Flight (Helicopters) |
| Hydraulics<br>Air Conditioning & Pressurisation | [1]AirFrames Systems (Aeroplanes) /<br>[2]AirFrames Systems (Helicopters) |
| Piston Engines & Supercharging<br>Gas Turbine Engines | Engines |
| DC Electrics<br>AC Electrics | Electrics |
| Loading | Loading ( No change) |

Notes:

1: *Principles of Flight (Aeroplanes) and AirFrames Systems (Aeroplanes) are applicable only for pilots applying for a CPL / ATPL (Aeroplanes).*

2: *Principles of Flight (Helicopters) and Air Frames Systems (Helicopters) are applicable only for pilots applying for a CPL / ATPL (Helicopters).*

**Revised Syllabi**

3. The examination syllabi for the new Aircraft Technical Group of Papers have been re-written more prescriptively to help candidates and training staff accurately identify the scope and depth of knowledge required for passing the respective examination. A copy of this AIC (with the new syllabi) may be downloaded from the CAAS website at www.caas.gov.sg or obtained by purchasing a copy of the Singapore Air Safety Publication Part II at S$6.00 (excluding GST) from the CAAS Airworthiness / Flight Operations Division, Licensing Section, Level 4 Terminal 2 #046-025, Singapore Changi Airport.

4. There is no change to the examination syllabi and format of the Performance A, Aviation Law, Flight Rules and Procedures, and Radiotelephony Theory subjects. Aircraft Type papers remain unchanged.

**Pass Rules**

5. A candidate must sit for all the five papers listed in paragraph 2 in the initial sitting and must pass at least three of these five papers in order to be awarded a partial pass in the Aircraft Technical Group of Papers. The passing mark for each of these papers is 70% with penalty marking.

6. A candidate will be allowed two further attempts to pass all the remaining papers within this group.

7. A candidate must attempt all outstanding papers of each group during each re-sit. A candidate who fails to convert a partial pass to a full pass within two further attempts will have to resit all papers in this group.

8. A candidate who fails to obtain a partial pass or convert a partial pass to a pass within 3 cycles will be barred for a period of 3 month before being permitted to resit the Aircraft Technical Group of papers.

9 The passing mark for the Performance A, Aviation Law, Flight Rules and Procedures and Radiotelephony Theory papers remain at 70% and the Aircraft Type paper at 75%. The penalty marking system is still applicable for these papers. These papers are required to be successfully completed within a 12-month period prior to the issue of a CPL or ATPL. These papers must be completed within three attempts failing which the applicant would be barred for a period of three months before being allowed to resit the failed paper again.

**Existing examination credits for the Aircraft Technical Group of Papers**

10. The new Aircraft Technical Group of papers will be applicable to all new candidates from 1 March 2003.

11. Licence holders and applicants with the existing Aircraft Technical papers examination credits will still be able to apply for the issue of a CPL / ATPL or a new aircraft rating before 1 March 2004. The existing Aircraft Technical Group of papers will be available to these candidates until 1 March 2004.

12. The existing Aircraft Technical Group of papers will not be available to new applicants applying for a CPL / ATPL after 1 March 2003.

13. Effective from 1 March 2004, candidates who require an examination credit for Variable Pitch Propellors, Gas Turbines or AC Electrics will have to sit for the new applicable examination paper in the new Aircraft Technical Group of Papers, which may include material already examined.

ALLAN TANG
for DIRECTOR-GENERAL OF CIVIL AVIATION
CIVIL AVIATION AUTHORITY OF SINGAPORE

# CIVIL AVIATION AUTHORITY SINGAPORE

# Professional Pilot's Licence Aircraft Technical Group: Study Information

**Revision 04 December 2002**

# Professional Pilot Ground Examination Syllabi, Sample Questions and Study References

## CONTENTS

## Study Information

This information booklet has been prepared to assist persons studying for the professional pilot Aircraft Technical Group examinations conducted by the Civil Aviation Authority of Singapore.

Each examination will examine the area of knowledge as detailed in the individual syllabus listed in this booklet.

There is a large amount of published information available (textbooks, papers or electronic media) on these subjects that will enable you to comply with each of the prescriptive clauses within the syllabi. It is important that you ensure that you study all syllabus items, as they provide the basis for the examination questions.

The following publication list of suitable texts covers all syllabus objectives in the subjects shown. The list is provided for candidate guidance only. It is neither exclusive nor exhaustive. Inclusion of a title in the list does not imply any endorsement of that publication. Conversely, non-inclusion of a publication in the list does not imply that it is not suitable for use as a study reference.

**Principles of Flight (Aeroplane)**

- Principles of Flight and Aeroplane Performance Vol 7 - Aviation Theory Centre.
- Mechanics of Flight, $10^{th}$ Edition – AC Kermode
- CPL Aerodynamics – Bob Tait

**Airframe Systems (Aeroplane)**

- General Aircraft Technical Knowledge Vol 8 - Aviation Theory Centre.
- Aircraft Systems & Components – D.F. Garrett
- A& P Technician Airframe Textbook - Jeppesen
- Aerodynamics, Engines & Airframe Systems for ATPL – Trevor Thom

**Engines**

- General Aircraft Technical Knowledge Vol 8 - Aviation Theory Centre.
- Aircraft Reciprocating Engines – Jeppeson
- The Jet Engine – Rolls Royce Limited
- Aerodynamics, Engines and Airframe Systems for the Air Transport Pilot - Aviation Theory Centre.

**Electrics**

- General Aircraft Technical Knowledge Vol 8 - Aviation Theory Centre.
- Electrical Systems for A& Ps – Jeppesen
- Aircraft Electrical Systems Single and Twin Engine – IAP Inc
- Avionics & Flight Management Systems for ATPL – Trevor Thom

**Principles of Flight (Helicoptger)**

- Principles of Helicopter Flight - Wagtendonk, ASA – PHF.
- Principles of Flight Vol 7 - Aviation Theory Centre.
- Basic Helicopter Handbook – FAA Publication AC 61-13
- Dynamics of Helicopter Flight – George H. Saunders

**Airframe Systems (Helicopter)**

- General Aircraft Technical Knowledge Vol 8 - Aviation Theory Centre.
- Principles of Helicopter Flight - Wagtendonk, ASA – PHF
- Basic Helicopter Maintenance – IAP Inc

## Tips For Answering Multi-Choice Questions

- Carefully read each question and each option before trying to identify the correct answer.
- The essence of multi-choice questions is not only to identify the correct answer but also to confirm that the other three options are incorrect.
- Those questions for which you know the answers should be attempted first so that the remaining time may be devoted to the more difficult questions within the paper.
- As penalty marking is employed in these examinations, if you do not know the correct answer to a question, it may be better to leave it rather than risk answering it incorrectly.
- Do not try to read too much into a question.
- Do not assume that one question will answer another elsewhere in the paper.

# Principles Of Flight – Aeroplane

| | |
|---|---|
| Number of questions: | 40 |
| Paper duration: | 50 minutes |
| Pass mark: | 70% - penalty marking employed. |

## Syllabus

**1.0** **Basic Aerodynamic Theory**

1.1 Describe the terms freestream static pressure, dynamic pressure (including the term ½ñ$V^2$) and total (or pitot) pressure.

1.2 Explain the principle of airspeed indication, and indicate the relationship between indicated, calibrated, equivalent and true airspeeds (IAS, CAS, EAS, and TAS).

1.3 With respect to aerofoils, describe the meanings of the following terms: section, leading edge, trailing edge, chord, chord line, thickness, thickness/chord ratio, camber, mean camber line.

1.4 Distinguish between high-lift, general purpose (GP) and high-speed aerofoil sections.

1.5 Define relative air flow and angle of attack ($\alpha$).

1.6 State Bernoulli's theorem in simple terms, and describe streamline flow, turbulent flow, and the application of Bernoulli's theorem to the streamline flow around an aerofoil.

1.7 Describe a venturi and explain venturi effect.

1.8 Explain the changes to the airflow and pressure distribution around a typical aerofoil in a low-subsonic speed airflow as $\alpha$ is increased from the zero-lift angle to beyond the stalling angle.

1.9 Explain the terms upwash and downwash in an airflow.

1.10 Explain the term centre of pressure (CP); and describe typical movement of the CP with increasing $\alpha$.

1.11 Define the total aerodynamic reaction force (TR) of an aerofoil.

1.11.1 Describe how TR varies with increasing $\alpha$.

1.11.2 Define the TR components lift and drag.

**2.** **Lift**

2.1 List the factors affecting lift (low-subsonic speed airflow).

2.2 State the lift formula, and the three basic factors contained within it.

2.3 Describe the meaning of the term coefficient of lift ($C_L$).

2.4 Given a typical $C_L$ versus $\alpha$ curve for a GP-type aerofoil, identify:

(a) the zero lift angle; and,

(b) the angle for maximum $C_L$ ($C_L$max).

2.5 State the meaning of a high $C_L$max.

2.6 With respect to the $C_L$ curve, describe the effect of:

(a) increased camber; and,

(b) surface roughness (e.g. contamination).

2.7 Describe three-dimensional flow over a wing and explain how wingtip and trailing edge vortices are formed.

2.8 Explain the effect of induced downwash on $\alpha$.

2.9 Define aspect ratio (AR) and describe the effect of AR on $C_L$

**3.0 Drag**

3.1 List the types of drag which go to make up total drag.

3.2 Explain the term boundary layer.

3.2.1 Describe:

(a) laminar boundary layer flow;

(b) turbulent boundary layer flow; and,

(c) transition point.

3.3 Explain skin-friction drag and state the factors affecting it.

3.4 Explain form drag; state the factors affecting it; and

3.4.1 Describe the effect of streamlining in reducing form drag.

3.5 Describe interference drag and the measures for reducing it.

3.6 Explain the origin of induced drag; and

(a) list the factors affecting it; and,

(b) explain typical measures for reducing it.

3.7 State the meaning of the term coefficient of drag ($C_D$); and describe the main features of a typical curve of $C_D$ versus $\alpha$.

3.8 State the drag formula, and the three basic functions contained within it.

3.9 Describe typical curves of induced, parasite and total drag versus IAS in straight and level flight.

3.10 Identify the speed for minimum drag and maximum lift/drag ratio.

3.11 Distinguish between curves for $C_D$ and total drag.

3.12 Explain a typical curve for lift/drag (L/D) ratio versus $\alpha$; and

3.12.1 Show the "most efficient" zero lift, and stalling angles.

**4.0 Lift Augmentation**

4.1 State the basic purpose of lift augmentation devices.

4.2 State the basic principle of operation of trailing and leading-edge flaps.

4.3 Explain the effects of lowering trailing edge flap on; $C_L$, $C_D$, L/D ratio, CP movement, angle of attack and nose attitude.

4.4 Distinguish between the effects of lowering leading-edge flap on angle-of-attack, nose attitude and movement of the CP with those of trailing-edge flap.

4.5 Identify the main types of trailing-edge flap and compare their relative performance (in generating lift and drag).

4.6 Identify the main types of leading-edge flap.

4.7 State the basic principle of operation of slats and slots.

4.8 Explain the effect of operating leading-edge slats on $C_L$, stalling angle and nose attitude.

4.9 Explain the principle of operation of spoilers and give examples of their typical use.

**5.0 Stability**

5.1 Explain static stability and dynamic stability.

5.2 Explain positive, neutral and negative stability.

5.3 Differentiate between stability and controllability.

5.4 Define longitudinal stability and explain:

(a) the action of the tailplane in maintaining longitudinal stability;

(b) wing pitching moments; and

(c) the effect of CG position.

5.5 Define directional stability and explain the factors affecting it.

5.6 Define lateral stability and explain the factors affecting it (dihedral, shielding, wing position, keel surface/fin area, sweepback).

5.7 Explain the requirement to match lateral and directional stability.

5.8 Explain the conditions of spiral instability, Dutch roll, and snaking.

5.9 With respect to stability and control on the ground, explain:

(a) the importance of CG position;

(b) the differences between nosewheel and tailwheel configurations; and

(c) handling of controls in strong crosswinds;

**6.0 Flight Controls**

6.1 State the three aircraft axes, movement about those axes, and primary flight controls.

6.2 Explain how control in pitch, roll, and yaw is achieved, and

6.2.1 Describe:

(a) the secondary effect of aileron;

(b) adverse yaw and methods used to counteract it; and,

(c) the secondary effect of rudder.

6.3 Describe the effects of airspeed and slipstream on control effectiveness.

6.4 Explain the principle of operation of trim tabs, and describe the correct method of using trim controls.

6.5 State the reason for proper aerodynamic balancing of control surfaces;

6.5.1 Describe the main methods for achieving control balance; and

6.5.2 Differentiate between a balance tab and an anti-balance tab.

6.6 Describe the need for mass balancing;

6.6.1 Distinguish between flexural and torsional flutter; and

6.6.2 Describe the methods of providing mass balance.

**7.0 Stall Warning and Recovery Systems**

7.1 Define the stalled condition of an aerofoil surface.

7.2 Define basic stall speed and relate it to the lift formula.

7.3 Describe typical symptoms and other indications of the approach to the stall.

7.4 Describe the changes in the airflow over the wing, movement of the CP, and aircraft attitude as the point of stall is reached.

7.5 Explain the standard recovery from the stalled condition.

7.6 Explain why some aircraft require a stall warning and recovery system.

7.7 Describe the principle of operation of stall warning systems.

7.8 Describe the principle of operation of stall recovery systems.

7.9 State the speed at which stall warning systems are required to be activated.

**8.0 Propellers**

8.1 Define blade face, blade back, blade angle, pitch (or helix) angle, helical twist, angle of attack.

8.2 Describe:

(a) the forces acting on a propeller blade;

(b) the rpm/airspeed relationship;

(c) the most effective blade sections

8.3 Explain how propeller pitch affects engine efficiency at different speeds.

8.4 Describe the effect on engine parameters of propeller pitch changes.

8.5 State the purpose of the constant-speed (variable pitch) propeller.

8.6 Describe in broad terms the operation of the constant speed unit (CSU) with changes in power setting and airspeed.

8.7 Describe the correct procedure for handling the manifold pressure and propeller controls.

8.8 Describe the forces acting in the:

(a) windmilling;

(b) feathered; and

(c) reverse thrust propeller modes.

8.9 Explain propeller centrifugal and aerodynamic twisting moments.

8.10 Describe asymmetric blade effect.

8.11 Explain the terms power absorption and propeller solidity.

## Sample questions – Principles of Flight (A)

**1** Angle of attack is the angular difference between the:

A chord line and the horizon.

B mean camber line and the flight path of an aircraft.

C mean camber line and the relative airflow.

D chord line and the relative airflow.

Correct Answer: **D**

**2** The best lift/drag ratio is found at approximately ____ degrees angle of attack.

A 2

B 4

C 8

D 16

Correct Answer: **B**

**3** The lowering of leading edge flap will **(i)**_______ separation, **(ii)**_______ the stalling speed and **(iii)**_______ the stalling angle of attack.

| | (i) | (ii) | (iii) |
|---|---|---|---|
| A | delay | reduce | increase |
| B | delay | increase | increase |
| C | hasten | reduce | reduce |
| D | hasten | increase | increase |

Correct Answer: **A**

**4** How does a forward centre of gravity affect an aircraft's longitudinal stability?

A Centre of gravity has no effect on stability.

B The shorter tailplane arm gives a stronger restoring moment and the aircraft is less stable in pitch.

C The longer tailplane arm gives a stronger restoring moment and the aircraft is more stable in pitch.

D The elevator deflections must overcome a smaller tailplane restoring moment, so the aircraft is easier to control.

Correct Answer: **C**

**5** How does slipstream affect control effectiveness on a single engine aircraft?

A The controls are not affected by the slipstream at all.

B All of the controls are more effective at low airspeeds.

C The ailerons are more effective at low power settings, especially at high airspeeds.

D The elevator and rudder are more effective at high power settings, especially at low airspeeds.

Correct Answer: **D**

**6** The propeller angle of attack is the angle between the:

A chord line and the plane of rotation.

B chord line and the relative airflow.

C plane of rotation and the direction of flight.

D relative airflow and the plane of rotation.

Correct Answer: **B**

## Airframe Systems – Aeroplane

| | |
|---|---|
| Number of questions: | 25 |
| Paper duration: | 30 minutes |
| Pass mark: | 70% - penalty marking employed. |

## Syllabus

**1.0 Airframes**

1.1 Explain five different types of loading to which an airframe must be designed to accept.

1.2 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.

1.3 Briefly describe the three styles of fuselage construction (truss; monocoque; and stressed skin (or semi-monocoque).

1.4 Briefly describe the three common types of wing construction (biplane; braced monoplane; unbraced monoplane (or cantilever).

1.5 Describe the function of the following wing components; spars, ribs; skin and stringers.

1.6 Briefly describe the construction of tailplane and fin, and control surfaces.

1.7 Briefly describe the layout of the primary control runs.

1.8 State the requirements which the undercarriage system must be able to meet.

1.9 Describe the features of simple light aircraft undercarriage construction and, given a diagram, explain the operation of an oleo-pneumatic shock strut.

1.10 Describe the pilot checks of oleo-pneumatic undercarriage legs.

1.11 Briefly describe the essential features of a retractable undercarriage system.

1.12 Briefly describe the construction of aircraft wheel assemblies and tyres.

1.13 State the requirements for tyre care and checks.

1.14 State the procedure for tie down (or picketing) a light aircraft.

**2.0 Support Systems**

2.1 Hydrodynamics:

(a) state Pascal's principle and,

(b) with the aid of diagrams:

2.1.1 describe mechanical advantage;

2.1.2 show how it can be gained hydraulically; and

2.1.3 demonstrate the principle of operation of aircraft hydraulic services.

2.2 Hydraulic systems:

(a) state the advantages of using hydraulics to operate aircraft services;

(b) differentiate between the three types of hydraulic oil; and,

(c) describe the function of common hydraulic system components; including:

reservoirs;

pumps;

pressure regulators;

accumulators;

check valves and relief valves;

elector valves;

actuators; and

filters.

2.3 With the aid of schematic diagrams, describe the operation of the following hydraulic systems:

(a) open centre system; and,

(b) pressurised system.

2.4 Pneumatic systems:

(a) briefly state the advantages and disadvantages of pneumatic systems versus hydraulic systems.

(b) outline the operation of the following pneumatic systems:

back-up systems;

low pressure systems and, with the aid of a schematic diagram,

a typical high pressure system.

2.5 Brake systems:

(a) state the basic principle of operation of wheel brake units;

(b) explain the operation of expander-tube and brake-shoe wheel units;

(c) explain the operation of disc brake units;

(d) outline the operation of;

an independent brake system;

a boosted brake system;

a power brake system; and,

(e) explain the operation of anti-skid units.

2.6 Ice protection systems:

(a) distinguish between anti-icing systems and de-icing systems;

(b) explain the operation and the proper handling of, mechanical, fluid and thermal ice protection systems; and

(c) describe ice detection, windscreen heating and rain clearance systems.

2.7 Fire protection systems:

(a) describe the principles, features and parameters of typical fire protection systems;

(b) outline the operation of unit-type and continuous loop fire detectors;

(c) list the common extinguishing agents and state any precautions when using; and,

(d) describe common fire extinguishing systems and the limitations with their use.

2.8 Air conditioning systems:

(a) explain the need for air conditioning in the cabin of an aircraft;

(b) explain the operation of vapour cycle cooling systems;

(c) state the advantage of vapour cycle cooling systems over air cycle systems; and,

(d) explain the operation of air cycle cooling systems.

2.9 Pressurisation systems:

(a) explain the need for pressurisation in the cabin of an aircraft;

(b) explain pressure differential and the limits on aircraft structures;

(c) explain pressurisation system operation;

(d) explain pressurisation system control; and,

(e) describe pressurisation system problems, including:

depressurisation;

negative pressure.

## Sample questions – Airframe Systems (A)

**1** A bending load is one that tends to:

A cause the sliding of one part over another.

B stretch a structural member.

C bend a structural member.

D compress a structural member.

Correct Answer: **C**

**2** According to Pascal’s Principle:

A liquid is compressible.

B if an external pressure is applied to liquid in a closed container, the pressure applied to it at any point is transmitted equally throughout the liquid.

C if an external pressure is applied to a given amount of liquid, its volume will reduce.

D if an external pressure is applied to a given amount of liquid, its volume will increase.

Correct Answer: **B**

**3** Anti-skid braking systems are used to:

A delay the application of hydraulic pressure until skidding has started.

B delay the application of hydraulic pressure until the aircraft is slow enough to avoid skidding.

C control the amount of pressure the pilot can apply to the brake pedals, thereby avoiding skidding.

D release the brake pressure whenever a sensor detects that a wheel is beginning to skid.

Correct Answer: **D**

**4** The actual force on an aircraft's structure, caused by cabin pressure differential, is calculated by:

A multiplying the internal surface area by the pressure differential.

B dividing the internal surface area by the ambient pressure outside the cabin.

C dividing the internal surface area by the pressure differential.

D multiplying the internal surface area by the cabin pressure.

Correct Answer: **A**

## Engines

| | |
|---|---|
| Number of questions: | 40 |
| Paper duration: | 50 minutes |
| Pass mark: | 70% - penalty marking employed. |

## Syllabus

**1.0 Engines – General**

1.1 State the basic difference between reciprocating (piston) and gas turbine (jet) engines.

1.2 Distinguish between the basic types of piston aircraft engine.

1.3 State the fundamental operating principle of the reciprocating (piston) engine.

1.4 With the aid of diagrams, identify the main components of a four-stroke cycle piston engine including: cylinders; pistons; cylinder heads; valves; spark plugs; connecting rods; crankshaft; camshaft and valve operating mechanism.

1.5 With respect to a four-stroke piston engine, state the meaning of the following terms: cycle; stroke; top dead centre (TDC) and bottom dead centre (BDC); bore; clearance and swept volumes; compression ratio; firing interval; firing order; manifolds; manifold pressure; crank angle.

1.6 Explain the operation of the four-stroke cycle.

1.7 Explain valve lag, valve lead, and the advantages of valve overlap.

1.8 Explain the term ignition timing and the need for spark advance.

1.9 Distinguish between detonation and pre-ignition, state the main causes of these conditions, and the reasons for avoiding them.

**2.0 Engine Performance**

2.1 Define the terms: force; work; power; energy; and engine torque.

2.2 Relate horsepower to kilowatts.

2.3 Define brake power.

2.4 Define rated power and explain ‘rated altitude’ or ‘critical altitude’.

2.5 Explain the following in broad terms: thermal efficiency; mechanical efficiency; and volumetric efficiency.

2.6 With the aid of a diagram, explain the relationship between typical brake power and power available curves.

2.7 Explain the general conditions for the most efficient engine operation.

**3.0 Carburation and Fuel Injection**

3.1 Explain the following in relation to fuel-air mixture ratios: ‘rich’ and ‘lean’; normal workable mixture ratio limits; the ‘chemically correct’ or stoichiometric ratio; the approximate ratios for maximum power output and best economy.

3.2 With the aid of a diagram, describe a typical carburettor mixture setting curve and show the operating area where detonation will occur.

3.3 With the aid of a diagram, explain the basic principle of operation of a simple float-type carburettor.

3.4 Explain the need for the following in an aero-engine carburettor.

(a) atomisation and diffusion;

(b) accelerating system;

(c) idling system;

(d) power enrichment (economiser) system; and

(e) mixture control and cut-off system.

3.5 State the two main disadvantages with use of a float-type carburettor in an aero-engine.

3.6 State the principal difference between a fuel injection system and carburetted systems.

3.7 Explain the principal differences between continuous flow fuel injection, and direct fuel injection systems.

3.8 List the advantages and disadvantages of using fuel injection systems in aero-engines.

3.9 State the correct use of the mixture control.

3.10 Explain the consequences of operating with over-rich and over-lean mixture settings.

3.11 With respect to carburettor ice, explain the process and the atmospheric conditions for the formation of:

(a) refrigeration (or fuel) ice;

(b) throttle ice; and

(c) impact ice.

3.12 Explain the normal symptoms of carburettor ice formation, and the correct use of the carburettor heat control.

**4.0 Induction and Exhaust Systems**

4.1 With respect to carburettor air intakes, explain the correct use of ram air, filter, carburettor heat.

4.2 List the reasons for a reduction in power when carburettor heat is operated.

4.3 In general terms, describe the function of the inlet and exhaust manifold.

4.4 Explain the importance of proper sealing of the exhaust manifold.

**5.0 Supercharging**

5.1 Explain the advantages, and the limitations of, supercharging.

5.2 Explain the basic principle of operation of exhaust-driven superchargers (turbochargers).

**6.0 Fuel Systems**

6.1 Distinguish between gravity-feed and pump-feed fuel systems.

6.2 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); and

(k) engine primers and priming systems.

6.3 Describe the importance of correct management of fuel selection.

6.4 List the actions recommended in the case of loss of power through faulty fuel selection.

6.5 Explain fuel octane ratings and performance numbers.

6.6 Explain the likely result of using a higher grade, or a lower grade, of fuel than that recommended for a given aircraft.

6.7 State the precautions which can be taken to avoid fuel contamination with water and other impurities.

6.8 State the special precautions which must be taken when fuelling from drum stock, and the avoidance of the use of non-approved plastic containers.

6.9 Describe the correct procedures to be used for carrying out a fuel check.

6.10 Describe the general rules for refuelling an aircraft, and the correct use of fuel tank dipsticks.

**7.0 Ignition Systems**

7.1 State the reasons for fitting independent dual ignition systems to aero-engines.

7.2 List the essential components of an ignition system.

7.3 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; and

(e) impulse couplings.

7.4 Describe the operation of the ignition switch(es) in the cockpit, and outline the correct procedures to be followed during magneto checks.

7.5 Describe the functioning of the starter motor, and outline the correct operation of the starter switch.

7.6 Describe the procedures and the precautions to be taken when hand-swinging a propeller to start an engine.

**8.0 Lubrication and Cooling Systems**

8.1 Explain the main functions of the engine oil system.

8.2 Describe the effect of temperature on the viscosity and lubrication qualities of oil.

8.3 Compare the features of the ashless dispersant (AD) oils used in piston aero-engines with straight mineral oil and detergent oils.

8.4 With respect to oil grades, differentiate between the commercial aviation numbers and SAE ratings.

8.5 Differentiate between a wet sump and a dry sump oil system.

8.6 With the aid of a diagram, briefly 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; and

(e) oil tank and filter.

8.7 Explain the need for periodic oil changes.

8.8 Describe the correct oil replenishment procedure.

8.9 Describe the likely results of operating an engine with:

(a) incorrect oil type; and

(b) incorrect oil quantity.

8.10 Describe the likely causes of:

(a) low oil pressure;

(b) high oil pressure; and

(c) high oil temperature.

8.11 Explain the relationship between a fluctuating or low oil pressure reading accompanied by a rise in oil temperature, and the actions which the pilot should take.

8.12 State the reasons why excessively high engine temperatures must be avoided.

8.13 List the ways in which heat from the combustion process is dispersed from a typical aero-engine.

8.14 For an air-cooled engine, explain the function of:

(a) cowling ducts and baffles;

(b) cooling fins; and

(c) pilot-operated cowl flaps.

8.15 Explain the general handling requirements for maintaining engine temperatures in the proper range, for aircraft:

(a) without CHT gauge or cowl flaps; and

(b) fitted with CHT gauge and cowl flaps.

**9.0 Propellers**

9.1 With the aid of a diagram, identify the following with respect to a propeller blade section:

(a) relative airflow and angle of attack;

(b) the rpm and TAS vectors; and

(c) the total reaction (TR) and its components, thrust and propeller torque.

9.2 State the two main disadvantages of the fixed-pitch propeller that the constant-speed (variable- pitch) propeller was designed to overcome.

9.3 For a constant speed propeller, differentiate between the functions of the propeller (pitch) control and the throttle (MAP) control, when the propeller is:

(a) in the constant-speed range; and

(b) below the constant-speed rpm range.

9.4 Explain how the constant-speed unit acts to change the pitch of the blades and maintain rpm:

(a) with changes to MAP; and

(b) with changes in airspeed.

9.5 Explain the basis for centrifugal and aerodynamic twisting moments on a propeller blade, and identify the direction in which they tend to twist the blade.

9.6 With the aid of diagrams, explain the method of operation of typical pitch-changing mechanisms.

9.7 With the aid of a diagram, explain the operation of a typical CSU governor.

9.8 With the aid of diagrams, show the forces acting on a feathered blade section, and with the propeller in the reverse thrust mode.

9.9 Explain the caution against applying power as the propeller blades are travelling from the normal thrust to the reverse thrust angle.

9.10 Describe the normal handling of the propeller pitch and/or manifold pressure controls:

(a) when the aircraft is on the ground;

(b) for ‘exercising’ the CSU;

(c) prior to take-off and landing; and

(d) when increasing or decreasing power in the air.

9.11 Describe the types of failure which can affect the CSU, including the conditions which can lead to a ‘runaway propeller’ and the required remedial action.

**10.0 Gas Turbine Engine Theory**

10.1 (a) Describe Newton’s third law of motion and its practical application as it relates to the operation of a gas turbine engine.

(b) Describe how gas undergoes changes in pressure, volume and temperature in accordance with Boyle’s and Charles’ Laws.

10.2 Describe each of the following and their application to gas turbine engine operation:

(a) Bernoulli’s Theorem;

(b) Brayton constant pressure cycle;

(c) the pressure-temperature cycle;

(d) open and closed cycles;

(e) kinetic energy;

(f) potential energy; and,

(g) thermodynamic laws.

10.3 Describe the relationship between velocity, pressure and temperature of air at subsonic, transonic and supersonic speeds.

10.4 Describe the changes to pressure, temperature and velocity of the gas flow as it passes through each section of a gas turbine engine.

10.5 Describe the changes in the airflow characteristics of velocity temperature and pressure through a parallel, divergent and convergent duct.

**11.0 Turbine Engine Types**

11.1 Compare the working cycle of a gas turbine engine and a piston engine.

11.2 Describe the comparative advantages of gas turbine engines versus piston engines for aircraft propulsion.

11.3 Describe the basic constructional arrangements of the following engine types:

(a) turbofan;

(b) ducted fan (high bypass ratio);

(c) prop fan;

(d) turbojet;

(e) turboprop; and,

(f) turbo-shaft.

11.4 Describe the operating parameters, propulsive efficiency characteristics and uses of each of the above engines.

11.5 Identify engines that fall into either the thrust-producing or torque-producing category.

11.6 Specify the approximate ratio of jet thrust to propeller thrust that may be obtained from a modern turboprop engine.

11.7 Describe the following mechanical arrangements of gas turbine engines:

(a) double-entry single-stage centrifugal turbojet;

(b) single-entry two stage centrifugal turboprop;

(c) twin-spool axial flow turboprop;

(d) single axial flow compressor, free turbine drive turboprop;

(e) single-spool axial flow turbojet;

(f) twin-spool by-pass turbojet (low by-pass ratio);

(g) aft fan turbojet; and,

(h) triple-spool front fan turbojet (high by-pass ratio).

**12.0 Turbine Engine Inlet Systems**

12.1 Describe the purpose, construction and principles of operation of the engine inlet duct.

12.2 Describe a sub-sonic divergent inlet duct.

12.3 Describe a supersonic convergent-divergent inlet duct.

12.4 Describe the purpose, construction and performance aspect of a Bellmouth Compressor inlet.

12.5 Describe the types of inlet normally used on the various modern gas turbine engines.

**13.0 Turbine Engine Compressors**

13.1 Describe the purpose of a compressor in a gas turbine engine.

13.2 Describe the basic principles of operation of centrifugal and axial flow compressors.

13.3 Describe the comparative advantages of centrifugal and axial flow compressors.

13.4 Describe the merits of combined centrifugal and axial flow compressor combinations in small gas turbine engines.

13.5 State typical compressor pressure ratios for the various types and configuration of gas turbine engines.

13.6 Describe the relationship between compressor ratio and specific fuel consumption.

13.7 Describe the compressor arrangements found on the various types of modern gas turbine engine.

13.8 Describe the purpose and function of:

(a) diffusers;

(b) impellers;

(c) inlet guide vanes;

(d) rotor blades;

(e) stator blades;

(f) variable inlet guide vanes;

(g) variable stator blades;

(h) rotating stator blades; and,

(i) bleed valves.

13.9 Describe the pressure and velocity changes through a centrifugal compressor.

13.10 State the reasons and advantages for multiple spool compressors.

13.11 Describe speed relationships between compressor sections and how these speeds may vary with changing atmospheric conditions.

13.12 For various types of compressor arrangements identify; Nc, N1, N2, and N3 and state whether each is HP or LP.

13.13 State the reasons why axial flow compressors have a higher number of stages and a typical pressure rise between stages.

13.14 Describe the relationship between pressure, temperature and velocity in an axial flow compressor.

13.15 State the reason for the decrease in size and increase in the number of compressor blades towards the rear of an axial flow compressor.

13.16 State the reason for the small pressure change per stage in an axial flow compressor.

13.17 Describe the purpose of compressor taper.

13.18 Describe cycle pressure ratio.

13.19 Describe the construction, operation and pressure ratios associated with low, medium and high bypass fans.

13.20 Describe typical compression ratios achieved in modern axial flow compressors and the factors that affect compression ratio.

13.21 State the conditions that are commonly known to produce compressor stall with particular regard to:

(a) compressor maintenance;

(b) blade damage;

(c) intake damage/restriction;

(d) engine handling/operation; and,

(e) fuel scheduling.

13.22 Describe how the various stall control systems reduce the possibility of compressor stall.

13.23 Describe the purpose, construction, location, operation, rigging and maintenance of the following stall control devices and what engines they may typically be found on:

(a) variable angle compressor vane systems;

(b) variable angle inlet guide vane system;

(c) bleed valves; and,

(d) bleed band.

13.24 Describe the effects of a dirty, worn or damaged compressor on SFC and power output.

**14.0 Turbine Engine Combustion Section**

14.1 Describe the operation of the combustion chamber.

14.2 Describe the constructional features, materials and principles of operation of the following types of combustion chamber:

(a) annular;

(b) turbo-annular;

(c) multiple Can;

(d) can-annular type; and,

(e) reverse-flow annular.

14.3 State the comparative advantages of each type of combustion chamber.

14.4 Describe the purpose, construction and operation of swirl chambers, air shrouds liners, interconnectors and discharge orifices.

14.5 Describe the uses of primary, secondary and tertiary air flow through or around a combustion chamber.

14.6 State the percentages of airflow used for cooling and combustion.

14.7 Describe how flameout is caused and prevented.

14.8 Describe lean and rich mixture flameout.

14.9 Describe types and causes of combustor generated emissions and pollutants.

**15.0 Turbine Engine Turbine Section**

15.1 State the function of the gas turbine section.

15.2 Describe meaning, the principles of operation and characteristics of the following gas turbine blade design:

(a) impulse;

(b) impulse-reaction; and,

(c) reaction.

15.3 Describe multi-stage gas turbines.

15.4 Explain the purpose and function of nozzle guide vanes and how the driving force for impulse and impulse reaction turbines is obtained from the gas flow.

15.5 Describe the most common type of turbine blade design and give reasons why this type of blade is preferred.

15.6 Describe how a turbine blade extracts energy from the gas stream and drives the wheel.

15.7 Identify factors that limit the power available from the turbine stage.

15.8 Explain the gas flow pattern through nozzle and blade assembly with particular emphasis on static pressure, temperature and velocity.

15.9 State the reasons for compressor-turbine matching and how it is achieved.

15.10 State why turbine assemblies increase in diameter towards the rear of the engine.

15.11 Describe the function of the following turbine assembly components:

(a) case;

(b) nozzle;

(c) shroud ring;

(d) tip shrouds;

(e) wheel;

(f) air seal;

(g) diaphragms; and,

(h) cones.

15.12 Describe how turbine blades, discs and nozzles are cooled using bleed air and modern cooling techniques such as film cooling.

15.13 Describe turbine case cooling.

15.14 Describe:

(a) compressor/turbine coupling shaft arrangements;

(b) knife edge seals; and,

(c) turbine blade twist and stagger/incidence angle.

15.15 Describe the various methods of turbine blade to disc attachment including:

(a) fir tree root (two types);

(b) De Laval bulb root; and,

(c) BMW Hollow blade.

15.16 Describe N1, N2 and N3 turbine arrangements.

15.17 Define turbine blade creep and state the causal factors for this condition.

**16.0 Turbine Engine Exhaust Section**

16.1 Describe the exhaust gas flow through convergent and divergent passages.

16.2 State the purpose and principles of operation of the following exhaust nozzle types:

(a) convergent;

(b) convergent-divergent;

(c) variable area; and,

(d) divergent (rotorcraft operation).

16.3 Describe the noise levels of different types of exhaust system and their means of noise suppression.

16.4 Describe the types of engine configuration that produce the highest and lowest EGTs.

**17.0 Thrust Reversers**

17.1 Describe thrust reversal.

17.2 Describe:

(a) the various types of thrust reverser;

(b) thrust reverser components;

(c) variations; and,

(d) means of application.

**18.0 Turbine Engine Fuel Systems**

18.1 Describe the relationship, location and function of the following gas turbine engine fuel system components:

(a) engine sensing variables;

(b) fuel control unit (hydro pneumatic, hydro mechanical and electro-hydro mechanical);

(c) fuel filters (HP and LP);

(d) fuel heater;

(e) governors and limiting devices;

(f) main fuel pumps (HP and LP); and,

(g) valves (throttle/pressurising/dump/shutoff).

18.2 State the basic requirements, arrangements and principles of operation of gas turbine engine fuel control/metering systems, including:

(a) acceleration scheduling and control;

(b) air density/altitude/OAT/airspeed compensation;

(c) overspeed governing;

(d) power limiting;

(e) shutdown control;

(f) starting control; and,

(g) temperature limiting.

18.3 Describe and state the comparative advantages of simplex and duplex type fuel nozzles.

18.4 State the ideal fuel/air ratio for a gas turbine engine.

18.5 State the effect of a change in specific gravity with respect to weight of fuel.

18.6 State the purpose of water-methanol injection.

18.7 State the purpose of adding methanol to water in water-methanol injection.

18.8 Describe the following properties in relation to gas turbine fuels:

(a) calorific value;

(b) corrosion characteristics;

(c) energy per lb or kg;

(d) specific gravity;

(e) vapour pressure;

(f) fire hazard;

(g) flash point; and,

(h) fuel icing.

18.9 State the differences between the various types of jet fuel and identify their common usage names.

18.10 Describe the purposes of additives in jet fuels and identify which are the most common for modern engine operations.

18.11 State the ground handling requirements and the safety precautions to be observed with the use of gas turbine engine fuels.

18.12 Describe the fuel system markings for jet fuels.

18.13 Describe the susceptibility of gas turbine fuels to water contamination over other types of aviation fuels.

18.14 Describe methods of fuel system contamination detection and control.

**19.0 Turbine Engine Lubrication Systems**

19.1 Describe the basic requirements, arrangements and principles of operation of typical gas turbine engine lubrication systems.

19.2 Compare the different properties/characteristics of oils used in turboprop, turbojet and turbofan engines.

19.3 Describe the relationship, location, function and principles of operation of the following gas turbine engine lubrication system components:

(a) oil cooler;

(b) oil cooler baffles;

(c) oil-fuel and oil-air heat exchangers;

(d) oil filters/screens (pressure and scavenge);

(e) oil jets;

(f) oil pumps (pressure and Scavenge);

(g) gear and rotor type pumps;

(h) total loss and micro-metering systems;

(i) oil system chip detectors and magnetic plugs;

(j) oil tanks;

(k) breather (including centrifugal type) and pressurisation systems;

(l) vent check valves;

(m) scavenge subsystem;

(n) valves (by-pass/check/relief);

(o) vent subsystem (air/oil separators); and,

(p) oil fed engine anti-ice systems.

19.4 State the reason most gas turbine engines use fuel to cool the oil in preference to air.

**20.0 Turbine Engine Starting, Ignition, Relight and Shutdown**

20.1 Describe why gas turbine engines require high-energy ignition systems.

20.2 Describe the general precautions and prestart checks prior to ground running a gas turbine engine.

20.3 Describe general procedures for starting, ground run-up and shutting down a gas turbine engine.

20.4 Describe what is meant by self-sustaining rpm and how this is achieved.

20.5 Describe why it is necessary to accelerate an engine up to sustaining rpm as quickly and uniformly as possible.

20.6 Describe the positive cockpit indications of light-up during start.

20.7 Describe the causes, indications, effects and remedial actions for the following defects:

(a) hung start;

(b) too rapid TGT rise;

(c) hot start;

(d) wet start;

(e) poor acceleration up to sustainable rpm;

(f) over temp;

(g) compressor stall during start;

(h) compressor surge;

(i) lack of ignition;

(j) tail pipe fire;

(k) flameout;

(l) overspeed;

(m) over torque; and,

(n) bleed band or bleed valve stuck in the open or closed position.

20.8 Describe the conditions under which a low energy ignition system should be turned on.

20.9 Describe the requirement and procedures for an engine re-light in the air.

**21.0 Turbine Engine Air Cooling and Sealing**

21.1 Describe the requirement for cooling and sealing of engine components.

21.2 Describe the uses of low and high pressure air for cooling and sealing.

21.3 Describe the types of air and oil seals.

**22.0 Turbine Engine Indicating and Instrumentation**

22.1 Describe the basic requirements, methods of operation, relationship and function of the following typical engine instrument systems:

(a) flow measuring instruments (pressure/volume, fuel and mass air flow sensing types);

(b) mechanical measuring instruments (engine RPM, torque and vibration);

(c) pressure measuring instruments (oil and fuel);

(d) power measurement (EPR, engine turbine discharge pressure or jet pipe pressure);

(e) horsepower or thrust measurement (torque gauges);

(f) temperature measuring instruments; and,

(g) turboprop ice warning systems.

22.2 Describe the following terms and their significance to the operation of gas turbine engines:

(a) TIT;

(b) ITT;

(c) TOT;

(d) EGT;

(e) JPT; and

(f) TET.

22.3 Describe the indications received in the cockpit of an engine operating with a dirty, damaged or contaminated compressor.

22.4 Describe how power loss is indicated on a gas turbine engine.

**23.0 Thrust Augmentation**

23.1 Describe the requirements for thrust augmentation.

23.2 Describe the methods used and components of thrust augmentation.

23.3 Describe how injected fluid actually increases power output of an engine.

23.4 Identify the power increase a modern water injection system may achieve.

23.5 Describe the effect that fluid injection has on performance and efficiency across the various stages of the engine.

**24.0 Turbine Engine Controls**

24.1 Describe the basic requirements, arrangements and principles of operation of the following engine controls:

(a) linkages and controls to and from the propeller co-ordinator/interconnector and fuel control unit;

(b) mechanical control inputs and outputs for electronic fuel control systems;

(c) thrust lever/throttle/power/condition lever cables and linkages;

(d) units and components interconnected for emergency shutdown;

(e) turboprop overspeed safety devices; and,

(f) integration of engine and propeller controls.

**25.0 Turbine Engine Performance**

25.1 Define the following terms and describe the relationship between them, and their application to engine operation:

(a) choked nozzle thrust;

(b) equivalent shaft horsepower;

(c) gross thrust;

(d) net thrust;

(e) resultant thrust;

(f) specific fuel consumption (SFC);

(g) thrust specific fuel consumption (TSFC);

(h) flat rated SHP;

(i) full rated SHP;

(j) thrust distribution; and,

(k) thrust horsepower.

25.2 Describe the effect of the following factors on gas turbine engine performance, specifically thrust and fuel flow:

(a) airspeed;

(b) ram effect;

(c) altitude;

(d) pressure;

(e) temperature;

(f) humidity;

(g) bleed air; and,

(h) air intake icing.

25.3 List the main factors that limit the power output of gas turbine engines.

25.4 Describe the propulsive efficiency of the following types of gas turbine engine:

(a) turboprop;

(b) high by-pass ratio turbofan;

(c) low by-pass ratio turbofan; and,

(d) turbojet.

25.5 Calculate SFC from given operating conditions.

25.6 Describe how specific thrust and SFC will be affected by increasing the compression ratio of an engine.

25.7 State the causes of the reduction in SFC with increasing airspeed in turboprop engines.

25.8 Identify components in a gas turbine engine that produce either forward propulsive, or rearward propulsive forces.

25.9 Describe how the rated thrust of an engine is derived from the calculation of forward and rearward forces.

25.10 Describe the approximate power requirements needed to drive the compressor on the various types of engine.

25.11 Define giving practical examples:

(a) by-pass ratio; and,

(b) engine pressure ratio and how/where it is measured.

25.12 Describe the effects of bleed air operation on engine performance.

**26.0 Turbine Engine Anti-icing Systems**

26.1 Describe the principles, features and parameters of typical ice protection systems.

26.2 Describe effects of anti-ice system operation on engine performance for the various types of gas turbine engine and how this would be shown in the cockpit.

26.3 Describe the common source of bleed air.

## Sample questions - Engines

**1** Valve lag involves the:

- A late closing of the exhaust valve.
- B early opening of the exhaust valve.
- C late opening of the inlet valve.
- D late closing of the inlet valve.

Correct Answer: **D**

**2** Why must the fuel primer be locked closed when the engine is running?

- A To ensure the fuel burn rate calculated in pre-flight planning is accurate.
- B To avoid the distraction of having to close it in flight.
- C To prevent excessive fuel being drawn into the cylinders, causing an over-rich mixture.
- D To allow the auxiliary fuel boost pump to be used in flight.

Correct Answer: **C**

**3** What is the purpose of the compressor in a turbine engine?

- A To maximise the ‘ram recovery’.
- B To increase the static pressure of the air that enters the engine.
- C To convert the chemical energy of the fuel into air pressure.
- D To provide the power required to drive the turbines and engine accessories.

Correct Answer: **B**

## Electrics

| | |
|---|---|
| Number of questions: | 25 |
| Paper duration: | 30 minutes |
| Pass mark: | 70% - penalty marking employed. |

## Syllabus

**1.0 Electricity and Magnetism**

1.1 Describe the systems that typically require electrical power in a light aircraft.

1.2 Explain the basis of an electrical current, and the direction of the current.

1.3 Describe the basic characteristics, using common terms [amps, volts, electro magnetic force (emf) and ohms], of an electrical flow.

1.4 State Ohm's law.

1.5 With the aid of diagrams, describe simple 'two-wire' and 'single wire' grounded electrical circuits.

1.6 Distinguish between direct and alternating current, and explain the terms 'Hertz' and 'rectification'.

1.7 Describe the properties of magnetism, including polarity, attraction and repulsion.

1.8 Distinguish between temporary and permanent magnets, and the properties of 'soft iron' and 'hard iron'.

1.9 Describe the terms magnetic field, magnetic flux, and permeability.

1.10 Explain 'electromagnetism' and with the aid of diagrams, show the lines of magnetic force around a straight conductor and a coil.

1.11 With the aid of diagrams, describe the principle of operation of an electromagnetic switch (or relay) and a solenoid switch.

1.12 State typical examples of their use in aircraft electrical circuits.

1.13 List the six ways in which an emf can be generated.

1.14 Explain the principle of electromagnetic induction.

**2.0 AC and DC Electrics**

2.1 With the aid of a diagram, describe the principle of operation of a simple alternator (a magnet rotating inside a loop conductor).

2.2 Show the features of a practical alternator, and explain how the AC output is normally rectified to provide DC

2.3 List and explain the quantities and units associated with AC electrics.

2.4 With the aid of a diagram, describe the principle of operation of a simple generator (a loop conductor rotating inside a magnet).

2.5 Show the features of a practical generator, and explain how the output is passed through a commutator to provide DC

2.6 List and explain the quantities and units associated with DC electrics.

2.7 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.

2.8 Explain the function and principle of operation of a basic electric cell ('battery').

2.9 Distinguish between primary and secondary cells, wet-cells and dry cells, lead-acid and nickel-cadmium (and similar) types.

2.10 Explain the meaning of:

(a) battery capacity; and

(b) thermal runaway.

2.11 Explain the basic features and operation of:

(a) a lead-acid battery; and

(b) a nickel-cadmium (nicad) battery.

2.12 State the advantages of Nicad batteries.

**3.0 Electrical Systems**

3.1 Explain the function(s) of the following in a typical aircraft electrical system:

(a) the battery;

(b) a ground power source;

(c) the alternator or generator;

(d) a bus bar;

(e) overvoltage protection;

(f) an ammeter (left zero and centre zero);

(g) a master switch (or battery/alternator switch); and

(h) fuses, circuit breakers and overload switches.

(i) transformers

(j) rectifiers

(k) inverters

3.2 Distinguish between the functions and interpretation of left-zero and centre-zero ammeters.

3.3 Distinguish between the functions and correct operation of a single battery master switch and split battery/alternator switches.

3.4 Distinguish between the way in which fuses, circuit breakers and overload switches operate.

3.5 Explain airmanship aspects 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; and

(e) ensuring the battery master is switched off before vacating the aircraft after flight.

3.6 Explain the diagnosis and correct handling of electrical malfunctions including:

(a) an excessive charge rate;

(b) alternator/generator failure; and

(c) blown fuse/popped circuit breaker.

# Sample questions - Electrics

**1** By convention, an electrical current is considered to flow from **(i)**_______ to **(ii)**______, which is the **(iii)**_______ the actual flow of electrons.

| | **(i)** | **(ii)** | **(iii)** |
|---|---|---|---|
| A | positive | negative | opposite direction to |
| B | negative | positive | same direction as |
| C | positive | negative | same direction as |
| D | negative | positive | opposite direction to |

Correct Answer: **A**

**2** A simple alternator incorporates a magnet rotating inside a loop conductor called a:

A rotor.

B stator.

C diode.

D electrode.

Correct Answer: **B**

## Principles Of Flight – Helicopter

| | |
|---|---|
| Number of questions: | 40 |
| Paper duration: | 50 minutes |
| Pass mark: | 70% - penalty marking employed. |

## Syllabus

**1.0 Basic Aerodynamic Theory**

1.1 Describe

(a) freestream static pressure;
(b) dynamic pressure (including the term $\frac{1}{2}\rho V^2$); and,
(c) total (or pitot) pressure.

1.2 Explain the principle of airspeed indication, and indicate the relationship between indicated, calibrated, equivalent and true airspeeds (IAS, CAS, EAS and TAS).

1.3 With respect to aerofoils, explain the meaning of:

(a) section
(b) leading edge;
(c) trailing edge;
(d) chord
(e) chord line;
(f) thickness;
(g) thickness/chord ratio; and
(h) camber.

1.4 Distinguish between symmetrical and non-symmetrical aerofoil section.

1.5 With the aid of a diagram, identify and explain the meaning of:

(a) relative air flow; and,
(b) angle of attack

1.6 State Bernoulli's Theorem in simple terms.

1.7 Describe streamline flow, turbulent flow, and the application of Bernoulli's Theorem to the streamline flow around an aerofoil.

1.8 Describe a venturi and explain venturi effect.

1.9 Explain the changes to the airflow and pressure distribution around a typical symmetrical aerofoil as the angle of attack is increased from the zero-lift angle of attack to the stalling angle.

1.10 Explain the terms upwash and downwash in an airflow.

1.11 Explain the term centre of pressure (CP) and describe typical movement of the CP with increasing angle of attack with a symmetrical aerofoil section and with a non-symmetrical aerofoil section.

1.12 Define aerodynamic centre.

1.13 Describe the total aerodynamic reaction force (TR) of an aerofoil.

1.14 Describe how TR varies with angle of attack.

1.15 Define the TR components of lift and drag.

1.16 Define the TR components of rotor thrust and rotor drag.

**2.0 Lift**

2.1 Explain the factors that affect lift in subsonic and transonic flow.

2.2 State the lift formula.

2.3 Explain the meaning of coefficient of lift (CL).

2.4 Describe the variation of CL with angle of attack for a symmetrical and non symmetrical aerofoil section.

2.5 Given a CL graph of symmetrical and non symmetrical aerofoil against angle of attack, show:
(a) the zero lift angle; and,
(b) the angle for maximum $C_L$ ($C_L$ max).

2.6 Explain the benefits of a high $C_L$ max.

2.7 Explain the effects of exceeding the critical (stalling) angle of attack.

2.8 Explain the effects of camber and surface roughness on CL.

2.9 Define aspect ratio.

2.10 Explain the effects of aspect ratio on CL.

2.11 Explain the main advantages of using the symmetrical blade section in light helicopters.

2.12 Explain the effects on the lift produced, as the rotor tip approaches transonic speeds.

**3.0 Drag**

3.1 State the drag formula.

3.2 Explain the meaning of coefficient of drag (CD).

3.3 Describe the types of drag which make-up total drag.

3.4 Explain parasite drag and describe its variation with airspeed.

3.5 Explain form drag and the main factors that affect it.

3.6 Describe the effect of streamlining on form drag.

3.7 Explain skin friction drag and the main factors that affect it.

3.8 Define boundary layer.

3.9 Describe laminar and turbulent boundary layer flow.

3.10 Define, and explain the location of the:
(a) transition point; and,
(b) separation point.

3.11 Explain tip vortices.

3.12 Explain induced drag and the main factors that affect it.

3.13 Describe the method of reducing induced drag.

3.14 Explain the combination of the three types of drag into the total drag curve.

3.15 Explain the effects on drag as the rotor tip approaches transonic speeds.

3.16 Given a graph of total drag against airspeed, identify the speed for minimum drag.

**4.0 Lift/Drag Ratio**

4.1 Define lift/drag (L/D) ratio.

4.2 Explain the relationship between the lift/drag ratio and the CL/CD ratio.

4.3 Explain why flight at best lift/drag ratio speed is most efficient.

4.4 Given a graph of lift/drag ratio against angle of attack of a symmetrical aerofoil section, show
(a) the ‘most efficient’ angle of attack;
(b) the zero lift angle of attack;
(c) the stalling angle of attack; and,
(d) the minimum drag angle of attack.

4.5 Explain the factors affecting the lift/drag ratio.

**5.0 Helicopter Rotor Discs – Terminology**

5.1 With the aid of a diagram, identify and explain the meaning of:
(a) tip path;
(b) tip path plane;
(c) axis of rotation;
(d) plane of rotation;
(e) shaft axis;
(f) disc area;
(g) blade (pitch) angle;
(h) coning angle;
(i) feathering axis;
(j) feathering;
(k) disc loading;
(l) blade loading;
(m) solidity;
(n) flapping;
(o) lead-lag (dragging);
(p) rotational airflow (Vr);
(q) induced flow;
(r) inflow angle;
(s) rotor thrust;
(t) total rotor thrust; and,
(u) rotor drag (torque).

**6.0 Forces Acting on a Helicopter Rotor**

6.1 With the aid of a diagram, identify and explain the forces acting on a rotor blade.

6.2 Explain how total reaction can be resolved into lift/drag and rotor thrust/rotor drag.

6.3 Explain the effect of a change of angle of attack and inflow angle on the rotor thrust/rotor drag ratio.

6.4 With the aid of a diagram, identify and explain the force opposing weight.

6.5 State and explain the four factors influencing rotor thrust.

6.6 Explain the relationship between rotor thrust, centrifugal force and coning angle.

6.7 State and explain the three factors affecting rotor RPM limits.

6.8 Explain how changes in the following factors affect rotor drag:
(a) disc loading;
(b) gross weight;
(c) altitude; and,
(d) configuration.

6.9 Explain ground effect.

6.10 Explain how ground effect affects inflow angle; angle of attack; rotor drag and the power required to overcome rotor drag.

6.11 Explain the effect of airflow over the disc on induced flow.

6.12 Explain translational lift.

6.13 Explain how translational lift affects inflow angle; angle of attack; rotor thrust and the power required to overcome rotor drag in level flight.

6.14 Explain the principle of operation of delta-3 hinges and offset pitch horns in reducing blade flapping.

**7.0 Anti-torque Tail Rotor**

7.1 Explain, with the aid of a diagram, the function of the anti-torque tail rotor.

7.2 Explain the effect of anti-torque on:

(a) power required; and,
(b) rotor rpm.

7.3 Explain the effect of the wind on tail rotor thrust.

7.4 Explain the meaning of:
(a) translating tendency (tail rotor drift); and,
(b) rolling tendency (tail rotor roll).

7.5 Explain design techniques that can compensate for translating and rolling tendencies.

7.6 Explain the influence of ground effect on the amount of tail rotor thrust required.

7.7 Explain the effect of a tail rotor failure in flight.

7.8 Describe pilot actions that may eliminate or reduce the effects of tail rotor failure in flight.

**8.0 Disc Control**

8.1 With the aid of a diagram, identify and explain the functions of:
(a) collective pitch/control;
(b) cyclic pitch/control;
(c) swashplate (control orbit);
(d) stationary star (non-rotating plate);
(e) rotating star (rotating plate);
(f) pitch link; and,
(g) pitch horn.

8.2 Explain the use of a control orbit in applying cyclic and collective pitch.

8.3 Explain the effect of collective and cyclic control movement on swashplate movement, total rotor thrust and disc orientation.

8.4 Explain the effect of control input on blade lead/lag behaviour in fully articulated rotor systems.

8.5 Explain the following causes of movement about the lead/lag hinge:
(a) conservation of angular momentum (coriolis effect);
(b) Hookes joint effect;
(c) periodic drag changes; and,
(d) random changes.

8.6 Explain phase lag and advance angle.

8.7 State the two main categories of vibration in helicopters.

8.8 Explain the causes and characteristics of vertical vibrations and lateral vibrations.

8.9 Describe the causes and characteristics of high frequency vibrations and engine vibrations.

8.10 Describe recommended pilot actions when confronted with vibrations.

**9.0 Hovering**

9.1 Define hover.

9.2 Describe the control inputs required during hovering flight.

9.3 Explain the meaning of in ground effect (IGE).

9.4 Explain the meaning of out of ground effect (OGE).

9.5 Explain the relationship between inflow angle and collective pitch.

9.6 Explain the following factors affecting ground effect:
(a) skid height agl;
(b) density altitude;
(c) aircraft weight;
(d) nature of the surface;
(e) slope of the surface; and,
(f) the wind.

9.7 Describe overpitching.

9.8 Describe:
- (a) the conditions likely to lead to over-pitching;
- (b) the symptoms of over-pitching; and,
- (c) the recovery technique for over-pitching.

9.9 Describe recirculation.

9.10 Describe:
- (a) the conditions likely to lead to recirculation;
- (b) the symptoms of recirculation; and,
- (c) the recovery technique for recirculation.

**10.0 Forward Flight**

10.1 Explain the arrangement of forces on the rotor and fuselage when:
- (a) transitioning into forward flight; and
- (b) in equilibrium in forward flight.

10.2 Describe the changes to blade angle and tip path as the disc is tilted with cyclic.

10.3 Explain:
- (a) flapping to equality;
- (b) dissymmetry of lift;
- (c) means of overcoming dissymmetry of lift;
- (d) flap-back (blow-back);
- (e) flap-forward; and,
- (f) reverse flow.

10.4 State the flight profile in which translational lift is experienced.

10.5 State the typical speed range through which translational lift is noticeable.

10.6 Explain the meaning of inflow roll (transverse flow effect).

10.7 State the speed range in which inflow roll is most pronounced.

10.8 Describe how inflow roll is compensated for by the pilot.

10.9 With the aid of the power available/power required curves:
- (a) identify the TAS for minimum and maximum straight and level flight; and
- (b) describe the factors that affect this TAS.

**11.0 Climbing and Descending**

11.1 Describe the forces acting on a rotor blade established in a vertical climb.

11.2 Define:
- (a) rate of climb; and,
- (b) angle of climb.

11.3 On the power available/power required curves, identify TAS for:
- (a) maximum rate of climb; and,
- (b) best angle of climb.

11.4 With the aid of power available/power required curves, explain the effects on rate of climb, angle of climb, and required TAS as applicable, of:
- (a) collective setting changes;
- (b) altitude;
- (c) aircraft weight;
- (d) density altitude;
- (e) angle of bank;
- (f) external loads; and,
- (g) the wind.

11.5 Describe the forces on the rotor disc in a vertical descent.

11.6 Define rate of descent and angle of descent.

11.7 With the aid of power available/power required curves, explain the effects on rate of descent, angle of descent, and required TAS as applicable, of:
(a) collective setting changes;
(b) altitude;
(c) aircraft weight;
(d) density altitude;
(e) angle of bank;
(f) external loads; and,
(g) the wind.

11.8 Define power check.

11.9 Describe:
(a) situations where a power check is necessary; and,
(b) the sequence of a power check.

**12.0 Turning**

12.1 Describe the forces acting on a helicopter in a level turn.

12.2 State the effect of angle of bank on rate of turn and power required.

12.3 Explain the factors involved in forward flight during a:
(a) steep turn: and,
(b) minimum radius/maximum rate turn.

12.4 Explain the effect of the following factors on the rate and radius of turn:
(a) altitude;
(b) gross weight;
(c) external loads; and,
(d) the wind.

12.5 State the effect of angle of bank on altitude, at a constant power and IAS.

12.6 Explain the effect of wind on indicated airspeed and translational lift during a turn.

12.7 Explain the effect of slipping and skidding on the rate and radius of turn.

**13.0 Transitioning to the Hover**

13.1 Explain the meaning and purpose of the flare.

13.2 Explain the effects of the flare on:
(a) rotor rpm;
(b) total rotor thrust; and,
(c) rotor drag.

13.3 Describe the causes of rotor rpm changes during the flare.

13.4 Describe a zero-speed landing.

13.5 Describe the power requirements during a zero-speed landing.

**14.0 Autorotation**

14.1 Define autorotation.

14.2 Describe the factors involved when transitioning into an autorotation from:
(a) the hover at altitude; and,
(b) forward flight.

14.3 Identify, on a diagram, the stalled, driven and driving regions (sections) of a rotor disc in autorotation.

14.4 Describe the forces acting on the stalled, driven and driving regions of a rotor in autorotation.

14.5 Describe the combined effect of all regions of a rotor in autorotation.

14.6 Explain the effect of airspeed on the angle of attack of a rotor blade during autorotation.

14.7 Describe the effect of forward flight on the distribution of autorotative forces.

14.8 Explain the effect of increased collective pitch on autorotation.

14.9 Explain the effect of rotor RPM and airspeed on autorotational rate of descent.

14.10 Explain the effect of increased altitude and increased weight on rotor RPM in autorotation.

14.11 Identify on a graph, range and endurance speeds for autorotation.

14.12 Explain the effect of the following factors on the range and endurance in autorotation:
(a) altitude;
(b) gross weight;
(c) parasite drag;
(d) external loads; and,
(e) the wind.

14.13 Explain the transition from autorotation to landing.

14.14 Describe the purpose of the Height/Velocity diagram (the avoid curve).

14.15 Explain the hazards involved in operations within the avoid curve.

14.16 Identify, on a graph of the avoid curve, boundaries of safe operation.

**15.0 Retreating Blade Stall**

15.1 Define retreating blade stall.

15.2 Explain the aerodynamic factors likely to lead to retreating blade stall.

15.3 Describe and explain the symptoms of retreating blade stall.

15.4 Explain the relationship between retreating blade stall and Vne.

15.5 Describe the recovery technique for retreating blade stall.

15.6 Explain the hazards of inappropriate control input during recovery.

**16.0 Vortex Ring State** (**Settling with Power**)

16.1 Define vortex ring state.

16.2 Describe the conditions that can lead to vortex ring state.

16.3 With respect to vortex ring state, describe:
(a) the development;
(b) the symptoms; and,
(c) the methods of recovery.

16.4 State the effect of power, weight and density altitude on vortex ring state.

16.5 Explain tail rotor vortex ring state.

16.6 List the conditions that can lead to tail rotor vortex ring state.

16.7 State the indications that differentiate between vortex ring state and a rotor stall.

**17.0 Ground Resonance**

17.1 Describe ground resonance.

17.2 Describe the conditions likely to cause ground resonance.

17.3 Describe the symptoms of ground resonance.

17.4 Describe the recovery technique for ground resonance.

**18.0 Blade Sailing**

18.1 Describe blade sailing.

18.2 Describe the conditions likely to lead to blade sailing.

18.3 Describe the recovery technique for blade sailing.

**19.0** **Dynamic Rollover**

19.1 Describe dynamic rollover.

19.2 Describe the conditions likely to lead to dynamic rollover.

19.3 Explain the factors influencing the critical angle at which dynamic rollover will occur.

19.4 Describe the recovery technique for dynamic rollover.

**20.0** **Cyclic Limitations**

20.1 Explain the factors that limit the available cyclic in the air and on the ground.

**21.0** **Mast Bumping**

21.1 Describe mast bumping.

21.2 Describe the conditions likely to lead to mast bumping.

21.3 Describe the forces involved during mast bumping.

21.4 Describe the means of avoiding mast bumping.

21.5 Describe the recovery technique for mast bumping.

**22.0** **Exceeding Rotor RPM Limits**

22.1 Explain the reasons for high RPM limits.

22.2 Explain the reasons for low RPM limits

**23.0** **Rotor Stalls**

23.1 Describe rotor stalling.

23.2 Describe the conditions likely to lead to a rotor stall.

23.3 Describe the symptoms of a rotor stall.

23.4 Describe the recovery technique for a rotor stall.

23.5 State the indications that differentiate between a rotor stall and vortex ring state.

## Sample questions – Principles of Flight (H)

**1** A rotor blade's chord line is the:

A line drawn between the upper and lower surfaces at the point of maximum thickness.

B line through which the blade tip passes.

C straight line drawn between the leading and training edges.

D straight line between the root and tip of the blade.

Correct Answer: **C**

**2** The best lift/drag ratio for a rotor blade is found at approximately ____ degrees angle of attack.

A 2

B 4

C 8

D 16

Correct Answer: **B**

**3** The shaft axis of a helicopter rotor is the:

- A line through the centre of the rotor shaft.
- B point about which the rotor blade is rotated.
- C line through the rotor head at right angles to the plane of rotation.
- D movement of the blade relative to the plane of rotation.

Correct Answer: **A**

**4** How does "ground effect" affect the power required to hover?

- A Ground effect has no relationship to hover power.
- B Ground effect reduces the power required to hover.
- C Ground effect causes fluctuations in hover power.
- D Ground effect increases the power required to hover.

Correct Answer: **B**

**5** In rotor systems incorporating lead-lag hinges, Coriolis effect (conservation of angular momentum) causes blades that are flapping:

- A down to move forward about the lead-lag hinge.
- B up to move backward about the lead-lag hinge.
- C to remain in a constant position relative to the lead-lag hinge.
- D up to move forward about the lead-lag hinge.

Correct Answer: **D**

**6** Blade sailing:

- A is a situation where low rotor RPM during startup or shutdown produces insufficient centrifugal force and flapping caused by the wind becomes excessive.
- B occurs when a helicopter, resting on the ground on one skid begins to move sideways, rolling around the skid, to the point where roll becomes uncontrollable.
- C is a vibration of large amplitude caused by a deliberate or unintentional oscillation of a helicopter in contact with or resting on the ground.
- D occurs when the helicopter’s main rotor hub is allowed to make contact with and deform the main rotor mast.

Correct Answer: **A**

## Airframe Systems – Helicopter

| | |
|---|---|
| Number of questions: | 15 |
| Paper duration: | 20 minutes |
| Pass mark: | 70% - penalty marking employed. |

## Syllabus

**1.0 Helicopter Airframes**

1.1 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.

1.2 State the requirements which the undercarriage/landing skid system must be able to meet.

1.3 Describe the features of simple light helicopter undercarriage/landing skid construction.

1.4 State the procedure for tie down (or picketing) a light helicopter.

**2.0 Transmission Systems**

2.1 State the purpose of a freewheeling unit.

2.2 State the purpose of a swashplate assembly.

2.3 State the purpose of a centrifugal clutch in a helicopter transmission system.

2.4 State the purpose of a rotor brake.

2.5 Explain the purpose of the main rotor gear box.

2.6 State the purpose and describe the principle of operation of the swashplate (control orbit).

2.7 State the most common method of cooling main transmissions.

2.8 Explain the procedures and reasons for the laboratory analysis of transmission oil samples.

2.9 State the reason for employing chip detectors in the transmission.

2.10 Describe the causes and symptoms of high frequency vibrations.

**3.0 Main Rotor Systems**

3.1 Describe the construction of modern helicopter rotor blades.

3.2 Describe the design features of:

(a) rigid rotor systems;

(b) semi-rigid rotor systems; and,

(c) fully articulated rotor systems.

3.3 Explain the causes of dragging in a fully articulated rotor system.

3.4 Explain the function of the blade damper in fully articulated rotor systems.

3.5 Explain the reason a semi-rigid (two-bladed) rotor system is frequently “under-slung”.

3.6 Explain the design feature (advance angle) which compensates for phase lag.

3.7 Explain the reason for rigging the rotor mast away from the vertical.

3.8 Describe the methods of chordwise and spanwise balancing.

3.9 Explain the reason for sweepback design near main rotor blade tips.

3.10 Explain the reason for washout in the design of main rotor blades.

3.11 Explain the advantages of employing a “delta-three hinge” in a fully articulated rotor system.

3.12 Explain the purpose of employing an “offset pitch horn” in a rotor system.

3.13 Explain the normal methods of trimming controls in a helicopter.

3.14 Describe the various methods of rotor stabilisation.

3.15 Describe the susceptibility of the various rotor systems to ground resonance.

3.16 Describe the susceptibility of the various rotor systems to mast bumping.

3.17 Describe the various types of vibration which may occur in a helicopter and explain their causes and possible remedies.

3.18 Describe the design feature employed to reduce vibration in semi-rigid rotor systems.

**4.0 Tail Rotor Systems**

4.1 Describe the construction of modern tail rotors and their hubs.

4.2 State the purpose of a “strike tab” on the tail rotor blades.

4.3 Describe the advantages and disadvantages associated with conventional exposed tail rotors.

4.4 Explain the advantages and disadvantages associated with shrouded (Fenestron) tail rotors.

4.5 Explain the reason asymmetric aerofoils tend to be employed on tail rotors and not on main rotors.

4.6 Describe alternative methods of anti-torque control.

4.7 Describe the effect of a jammed or failed tail rotor.

4.8 Describe the design features which can be employed to reduce tail rotor roll.

**5.0 Hydraulic Systems**

5.1 State Pascal’s principle.

5.2 With the aid of diagrams, describe mechanical advantage, and show how it can be gained hydraulically.

5.3 Demonstrate the principle of operation of aircraft hydraulic services.

5.4 State the advantages of using hydraulics to operate aircraft services.

5.5 Differentiate between the three types of hydraulic oil.

5.6 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; and,
- (h) filters.

5.7 With the aid of schematic diagrams, describe the operation of the following hydraulic systems:

- (a) open centre system; and,
- (b) pressurised system.

**6.0 Pneumatic Systems**

6.1 Briefly state the advantages and disadvantages of pneumatic systems versus hydraulic systems.

6.2 Outline the operation of the following pneumatic systems:

(a) back-up systems;

(b) low pressure systems; and

(c) high pressure systems.

**7.0 Fire Protection Systems**

7.1 Outline the operation of unit-type and continuous loop fire detectors.

7.2 List the common extinguishing agents and state any precautions when using them.

7.3 Describe common fire extinguishing systems and the limitations with their use.

## Sample questions – Airframe Systems (H)

**1** A hydraulic system creates a mechanical advantage by:

A compressing the fluid in the system.

B using a small force to create a larger force elsewhere.

C using a large force to create a small force elsewhere.

D connecting one hydraulic cylinder to another of equal size.

Correct Answer: **B**

**2** The function of an actuator in a hydraulic system is to:

A provide a reserve of hydraulic pressure when needed.

B prevent reverse flow in the system.

C convert pressure energy in the hydraulic fluid into a mechanical force with which to do useful work.

D regulate the fluid pressure to prevent system damage.

Correct Answer: **C**

**3** A compression load is one that tends to:

A compress a structural member.

B stretch a structural member.

C twist a structural member.

D cause the sliding of one part over another.

Correct Answer: **A**

**4** The function of a freewheeling unit in a helicopter transmission is to:

A allow the pilot to control contact between the engine and the driveshaft.

B automatically disengage the engine from the main rotor when the engine rpm is less than the main rotor rpm.

C slow down the main and tail rotor rpm on shutdown.

D transfer pilot cyclic and collective input to the blades.

Correct Answer: **B**