

**TEACHING NOTES FOR
"QUALIFIED GLIDER PILOT"
CERTIFICATE GROUND COURSE**



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Gliding Club Inc.

INTRODUCTION

This course consists of five parts, which correspond to the five parts of the examination papers set by the NZGA. The course is based on the requirements of the training syllabus and the prescribed examinations. It is referenced where appropriate to the QGP study manual.

The NZGA examinations for QGP certificate.

There are five exam papers prescribed, each dealing with one part of the course, and each consisting of **twenty** questions. To obtain a pass in each paper you must answer correctly at least **fourteen** questions from that paper. The questions and answers in the exam paper are of the multiple-choice format, and should present you with no difficulty if you have attended and understood this course of lectures. Two hours is allowed for the answering of each paper. Examinations for any part may be arranged with any instructor of the Club.

This course does NOT cover radio telephone or transponder procedures or material for the sitting of a Flight Radio Telephone Operators (FRTO) rating. That rating (required for the QGP certificate) is obtained through a flight training establishment such as a flying school, which will also provide the necessary study materials.

The five parts of the course are–

1. Air Law – Operational rules and procedures.
 2. Airmanship and navigation.
 3. Technical knowledge (Principles of flight, glider construction and limitations.)
 4. Meteorology.
 5. Human Factors (Human beings in the aviation environment.)
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Note for Course Instructors:

You will find the following aids most helpful in teaching QGP theory courses:

1. Copies of the Appendices in these notes as handouts.
2. Current and recent VTC and 1:500,000 aeronautical charts (preferably one of each type between two students)
3. A Whiteboard.
4. A small globe of the earth.
5. A model aeroplane (preferably a glider)
6. Pictures of cloud types.

PART I – AIR LAW.

ABBREVIATIONS USED IN THIS COURSE AND IN AVIATION GENERALLY.

Before we begin we will need to be familiar with a number of abbreviations used in aviation.

[HANDOUT APPENDIX I – ABBREVIATIONS]

AIR LAW

A glider is an aircraft for the purposes of our law, and a glider is therefore subject to many of the rules and regulations governing aircraft generally.

The sources of air law

- Civil Aviation Act 1990
- Civil Aviation Rules
- Advisory Circulars.
- AD's.
- NZAIP–Planning manual, IFG, VFG, etc.
- NOTAMS
- AIP Supplements
- NZGA's Manual of Approved Procedures (MOAP).
- GNZ Advisory Circulars
- Club Local Flying Rules.

The important thing to remember is that, unless gliders are specifically exempted from the operation of any particular rule, then all of the above rules will apply equally to gliders as to other aircraft. Much of the content of the NZAIP is extremely relevant and important to glider operations, e.g.–

- ECT times.
- RTF frequencies and procedures.
- VMC minima.
- Ground to air signals (by ATC, and for SAR purposes etc).
- GAAs, GFAs etc.

NOTAMS–contain information of a more **urgent nature**, e.g. information affecting flight safety (such as airfield closures, holding of gliding competitions etc.)

AIP Supplements – contain a wide range of general information of a **non-urgent nature**, e.g. long-term obstructions such as the Skytower, air shows, flying competitions, military exercises etc.

CONTROLLED AIRSPACE.

- Why do we call such airspace "controlled"?
- Who controls it?
- How?

Airspace division

Flight Information Regions (FIR)

A flight information region is an airspace of defined dimensions within which flight information service and an alerting service is provided. New Zealand has one domestic FIR, and is surrounded by the Auckland Oceanic FIR.

The New Zealand FIR

The New Zealand FIR is divided into four classes of airspace–

- | | | |
|-----|--|---------------------------------------|
| (a) | Controlled airspace (class C) | [100% ATC service, including radar] |
| (b) | Controlled airspace (class D) | [80% service – no radar] |
| (c) | Controlled airspace (class E) | [50% ATC service, e.g. at night only] |
| (d) | Uncontrolled airspace (class G) | [10% ATC service, e.g. ChCh info.] |

Controlled airspace is further divided into four types–

(a) **Upper Control Areas (UTA) – Class C airspace.**

UTA's are airspace above 9500 feet within which only authorised flights are permitted.

(b) **Terminal Control Areas (TMA) – Class C or D airspace.**

TMA's are airspace below 9500 feet within which only authorised flights are permitted.

(c) **Control Areas (CTA) – Class E Airspace.**

CTA's are controlled airspace within which **VFR** flights are **Not** subject to control by **Day**.

(d) **Control Zones (CTR) – Class C or D airspace.**

CTR's are controlled airspace about one or more aerodromes within which only authorised flights are permitted.

Depiction of controlled airspace on maps, charts, and NZAIP

Controlled airspace is depicted on maps and charts by the type, followed by a “/”, followed by the class. We will shortly be seeing these on actual charts.

[HANDOUT APPENDIX II – AIRSPACE CLASSIFICATION EXAMPLES]

Further explanation of controlled airspace categories.

(a) Control areas.

A control area is a controlled airspace of defined dimensions extending upwards from a specified lower limit.

(b) Terminal Control Areas.

A terminal control area is a control area normally established at the confluence of air routes in the vicinity of one or more major aerodromes.

(c) Control Zones.

A control zone is a controlled airspace of defined dimensions extending **upwards from the surface of the earth to a specified limit.**

Control zones may have other subdivisions, such as VFR transit lanes (Victor lanes), or VFR helicopter lanes (Kopter lanes). Generally These VFR lanes are not controlled. That is, flights may be conducted without reference to an ATS unit. They are treated as uncontrolled airspace for the purposes of “met minima”, but are not much used by gliders because they are generally restricted in altitude, e.g. to a maximum of 1000 or 1500 feet AMSL.

“TRANSPONDER-MANDATORY” AIRSPACE [MOAP, page 2-6-2]

A list of “transponder-mandatory” airspace is so full that transponders should be considered mandatory in all controlled airspace except CTA/E, although in some of those it will be mandatory also. In the case of CTA/E airspace RTF contact with ATC must be maintained if no transponder is available, and the rules for that particular airspace permit that course.

Flight in “transponder-mandatory” airspace is prohibited without an operating transponder without the approval of the appropriate ATS unit. At present only Mode A (ident only), and not mode C (altitude encoding) is required in gliders, although this is expected to change soon.

The operation of transponders will be covered in courses dealing with radio procedures. A good brief outline is provided in the December 1994 issue of the AGC club newsletter.

Depiction of “transponder-mandatory” airspace on aeronautical charts.

Transponder mandatory airspace is depicted on the latest charts by a different colouring of the classification designation lettering, or by the letters “TM” after the designation lettering.

The Rules for flight in controlled airspace.**(a) Control zones CTR’s**

In general glider flying is **prohibited** unless a **prior ATC clearance** is given, **or** unless the flying takes place **within a Glider Flying Area** (see below for GFA's). The pilot in command **must** obtain a clearance from the appropriate ATC unit **prior to entry into the zone**, and **must** comply with the terms of any such clearance and with any subsequent instructions received from ATC. (Hence the need for two-way RTF communication, and RRTO ratings).

In some control zones glider flying is prohibited, except under very special conditions, e.g. **Auckland, Wellington, and Christchurch CTR/C**.

[MOAP, page 2-6-1]

Pilots must inform ATC when they are **vacating** the control zone.

(b) Control areas TMA’s, UTA’s

To all intents and purposes the same basic rules apply to **TMA’s** and **UTA’s**. Entry into a control area requires a **prior ATC clearance**. The pilot must maintain a continuous listening watch on the appropriate ATC RTF frequency, and must give a position report every **30 minutes** stating–

- (i) identification**
- (ii) position**
- (iii) altitude**
- (iv) intentions** [MOAP, page 2-6-2]

Additional position reports are required whenever flight conditions produce any significant change in level. Pilots must inform ATC when they are **vacating** the control area.

(c) Control areas (visual exempted) (CTA/E)

This means just what it says – All aircraft (including gliders) operating under Visual Flight Rules (VFR) by day do not require a clearance to operate in these areas. However, it **MUST** be remembered that some parts of CTA/E are “transponder-mandatory” airspace. Either an operative transponder or a clearance from the appropriate ATS unit is required. For all practical purposes CTA’s/E should be treated as “transponder-mandatory”.

GENERAL AVIATION AREAS (GAAs) AND GLIDER FLYING AREAS (GFAs),

These are areas established within controlled airspace to enable glider flying or general aviation without reference to ATC. Although they are outside of that controlled airspace for control purposes, they may be subject to restrictions of their own.

For example, For instance, some GFAs and GAAs are permanently established and active during daylight hours, and have no restrictions on their use – e.g. ARDMORE G275, which coincides with the Ardmore Training area.

Some of these areas are activated by ATC on notification by the intended user, e.g. HUNUA G276. Others may require an ATC clearance to use them.

The important things to remember about GFAs and GAAs are:

- (1) Their conditions of use may vary throughout the country, and just because you see a GFA or GAA on a chart that does not necessarily mean that you can use it without restrictions; and
- (2) Airspace in GFAs or GAAs may not be reserved exclusively for use by gliders. It may generally be shared by any other VFR traffic.

The dimensions and conditions of use of all GFA's are contained in the **Planning Manual**.

SPECIAL TRAINING AREAS.

Special training areas may be established, such as low-flying areas or aerobatic training areas.

As far as gliders are concerned, they are very similar to GFA's, but may be shared with other types of aircraft.

[EXPLAIN DIFFERENT TYPES OF AERONAUTICAL CHARTS and their uses, e.g. 1:500,000, 1:250,000 VTCs, ERCs ETC]

AERONAUTICAL CHARTS.

[DISTRIBUTE COPIES OF VTCs AND AERONAUTICAL CHARTS FOR A THOROUGH DISCUSSION OF THE DIFFERENT TYPES OF AIRSPACE (INCLUDING UNCONTROLLED), GFA's ETC, AND OF WHOM TO CALL FOR CLEARANCE FOR EACH TYPE.]

VTCs – visual terminal charts.

Visual terminal charts are the most important of the aeronautical charts you will use in flying. They are the largest scale, and therefore the most detailed.

Visual Terminal Charts show airspace **below 9500 ft** in the vicinity of major airports.

They also show all of the relevant types of airspace that you will need to be aware of, and other types of airspace restriction which we will now discuss.

[WHILST THE CLASS STILL HAVE THE CHARTS IN FRONT OF THEM, MOVE ON TO THE NEXT TOPIC OF OTHER RESTRICTIONS ON THE USE OF AIRSPACE]

OTHER RESTRICTIONS ON THE USE OF AIRSPACE.

Apart from controlled airspace, there are other restrictions on where we may fly, e.g.–

- (a) Danger Zones**
- (b) Restricted areas**
- (c) PDZs**
- (d) Instrument Approach Restricted Areas (IARAs)**
- (e) Designated Low Flying Areas**

Danger areas and restricted areas are often temporary in nature and will be advised by NOTAM.

Restricted areas are usually more permanent, e.g. wildlife sanctuaries, oil refineries, frequently used military target practice areas etc.

[IDENTIFY SOME DANGER ZONES AND RESTRICTED AREAS FROM THE CHARTS, AND DISCUSS REFERENCE TO THE PLANNING MANUAL FOR FURTHER DETAILS OF THESE AREAS.]

Temporary restricted areas may be established, for example, for gliding competitions. These may allow gliders to fly in cloud under certain conditions without reference to ATC.

VFR VISIBILITY REQUIREMENTS.

Gliders, like all other aircraft when flying visually (VFR), must observe certain visibility and distance from cloud criteria. When flying within these criteria, an aircraft is said to be flying in Visual Meteorological Conditions (VMC). If not flying "visually", i.e. within VMC, then it is said to be flying in Instrument Meteorological Conditions (IMC).

[HANDOUT APPENDIX III – FROM MOAP, Page 2-6-1]

[ADVISE THAT THIS TABLE MUST BE LEARNED THOROUGHLY FOR THE EXAM!]

CLOUD FLYING (IMC).

There are a number of restrictions on the flying of gliders in cloud (IMC). They are discussed in the MOAP, section 2-7-5, and we will discuss these now.

General area restrictions.

Cloud flying is generally only permitted–

- (i) Outside of controlled airspace. (except the Auckland and Wellington CTA/E).**
- (ii) Within a GFA approved for cloud flying by the Director of Civil Aviation.**
- (iii) Within a restricted area specially promulgated and activated for the protection of glider flying and authorising cloud flying.**

Such restricted areas are usually established for national and regional competitions, and usually permit cloud flying without reference to ATC. During the period of the restriction other aircraft (traffic) are warned to keep clear, and may be restricted to VMC operations to avoid conflict with any cloud flying gliders.

Aircraft and pilot requirements. [PSN, page 7]

- (i) The aircraft's C. of A. must permit cloud flying.**
- (ii) The glider must be equipped with–**
 - 1. An ASI.
 - 2. A variometer.
 - 3. A sensitive altimeter.
 - 4. A magnetic compass.
 - 5. A turn and slip indicator OR an artificial horizon.
 - 6. A radio for two-way communication to an ATS unit (except when flying in an especially established restricted area, e.g. for gliding competitions).
- (iii) The occupants must wear parachutes and have received instruction in parachuting procedures.**

ATS confirmation that no IFR traffic nearby.

Except in especially established areas, no glider shall enter cloud (or IMC) unless the pilot in command has first obtained confirmation by radio from the nearest ATS unit that there is no IFR traffic in or about the proposed area of

cloud flying. So long as the glider remains in cloud (or IMC), then this confirmation from ATS must be renewed at least every 15 minutes.

Cloud flying within 10 km of a gliding site.

- (i) No glider within 10 km of a gliding site shall enter cloud except from at least 200 feet below the lowest part of the cloud.
- (ii) In addition to the above requirement for confirmation from an ATS unit for IFR traffic, the pilot shall broadcast position, altitude, and intention on the appropriate glider frequency, and shall repeat that information every 15 minutes. and again on re-entering VMC.

RULES OF THE AIR. [PSN, PAGE 16]

You should know the following rules of the air, both for the exam and for your general flying–

- (a) Give-way rules
- (b) Overtaking rules
- (c) Ridge flying rules
- (d) Thermalling rules
- (e) Formation flying rules
- (f) Aerobatic rules
- (g) Night flying rules
- (h) Regulation ceiling without oxygen

OPERATION FROM CONTROLLED AERODROMES.

- ATC clearances are required for take-offs etc.
- Light signals from control tower -

[EXPLAIN AND DISCUSS THESE FULLY]

THE GLIDING "ARROW".

A large white plastic or fabric arrow as specified in the MOAP (page 2-8-1) is now an optional signal to be displayed as a signal to aircraft in the vicinity that–

- (a) Gliding is in progress
- (b) Gliders are landing and being launched in that direction
- (c) Tow lines may be on the ground parallel to the direction of the arrow

NORMAL OPERATING RULES FOR GLIDERS. [PSN, pages 16-17]

By solo stage you should be thoroughly familiar with the following procedures–

- (a) Standard cockpit checks
- (b) Standard launch signals
- (c) “Pre-landing checks”
- (d) Aerobatic checks [ELABORATE AND EXPLAIN]
- (e) Emergency signals on aerotow

[HANDOUT APPENDICES IV AND V TO THIS PART]**TAKE-OFF PERFORMANCE REQUIREMENTS.**

There are certain take-off performance requirements for towplanes towing gliders and airfield lengths etc. The main rule is that the field must be of sufficient length to enable the combination to climb to 50 feet of altitude within 85% of the length of run available.

PILOT QUALIFICATIONS. [PSN, PAGE 20]

- (a) Every pilot must have a log book and keep the entries up to date.
- (b) Until you gain your QGP certificate you may not handle the controls of a glider in flight except under the direct supervision of a qualified gliding instructor.
- (c) No person may fly solo under the age of 14 years.
- (d) No person may fly solo without producing a medical declaration in the prescribed form.
- (e) A medical declaration

A medical declaration in the prescribed form is required for before going solo. It does not require renewal unless the pilot’s health changes to such a degree that it significantly affects his ability to fly an aircraft.

The MOAP prescribes qualifications for such things as–

- (i) Passenger ratings
- (ii) Instructor ratings
- (iii) Cloud flying ratings etc.

Some clubs may have their own rules for these qualifications, but these must be at least as strict as those laid down by the **MOAP**.

Cross-country operations–

- (i) All operations beyond a 10 Nm (20 km) radius of a gliding site are classed as cross-country operations. [Note that the Auckland Gliding Club defines cross-country operations more restrictively in terms of a 10 km radius.]
- (ii) A QGP certificate is a minimum requirement for the pilot in command of a cross-country flight.
- (iii) The prior authorisation of an instructor is also required.

OFFICIAL OBSERVERS, FAI BADGES, SPORTING LICENCES ETC

A note on these can be found on page 7 of the PSN. They are **not** required for the exam.

APPROVED TEST PILOTS.

All new gliders and gliders which have undergone major repairs or adjustments or work for the renewal of a C. of A. must be test flown by an approved test pilot. A list of approved test pilots can be found in the **MOAP**.

GLIDER DOCUMENTS.

Every glider must have and carry with it at all times–

- (a) A valid certificate of airworthiness
- (b) A valid Technical Log (includes release to service).
- (c) A daily inspection book
- (d) The flight manual for that particular glider (unless all required placard information is visible in the cockpit).

In addition, every glider must have an aircraft logbook in which is recorded all major repairs, modifications, special inspections etc.

N.B. – Unapproved modifications will invalidate the C. of A. and release to service.

FIRST AID KIT.

Gliders must carry a first aid kit. The contents of the kit are prescribed by **MOAP** and **AC's** etc. The kit includes the ground to air emergency signalling code.

The first aid kit must be inspected annually by a doctor, nurse or a chemist, and recorded in the aircraft logbook.

REGISTRATION MARKS

All aircraft, including gliders, must carry registration marks. In the case of gliders, the final two letters of the registration mark must be painted on each side of the fin and rudder combined.

RIGGING AND DE-RIGGING.

Rigging and de-rigging is a normal operation peculiar to gliders. Every rigging must be recorded in the D.I. book along with the D.I. before the next flight.

A duplicate inspection of all attachments and control connections must be carried out by another person who is qualified in their own right to carry out the D.I., and the duplicate inspection must be signed off in the D.I. book by the person carrying it out.

ACCIDENTS AND INCIDENTS [PSN, PAGE 23; MOAP, PAGE 2-7-7]

An accident or incident is any event which has **(or which might have)** caused injury to any person or damage to the aircraft.

Included in this concept are incidents of **careless handling**, or **severe flight** or **landing loads**, including **“gear up” landings**. All cases of severe flight loads, heavy landings, or “gear up” landings must be reported to an approved engineer who will make an inspection and carry out any necessary rectification work **prior to further flight**.

Any damage or suspected damage incurred during transport, ground handling, or rigging must be attended to by an approved engineer **prior to further flight**.

Anything causing doubt as to serviceability must be referred to an approved engineer.

Reporting of accidents and incidents.

(a) To NZGA operations committee. [MOAP, page 2-7-7]

All accidents and incidents must be reported by the club CFI to the NZGA operations committee (Regional or National Operations Officer), or by the contest director if occurring during gliding competitions. Initial reporting should be as soon as possible by phone or FAX, and then followed up by written advice on form FS 1 within 10 days of the event.

(b) To Civil Aviation Authority (CAA). [MOAP, page 2-7-7]

The pilot in command of any aircraft involved in an “accident” or “incident” (or the operator if the pilot is incapacitated) must advise the CAA of the details of the accident or incident as soon as practicable, but not later than 24 hours of it occurring. The initial contact should be by telephoning the 24 hour toll free number set aside for the sole purpose of notification of aircraft accidents and serious incidents: **0508 222 433**.

The initial notification must be followed up with written notification on the prescribed form within 10 days of the accident.

(c) To the police. [MOAP, page 2-7-7]

In case of any injury or property damage the local police should also be informed.

Custody and removal of damaged aircraft.

Aircraft damaged in accidents must be considered to be in the custody of CAA until released. No part of any such aircraft should be removed or disturbed except by authorised persons [MOAP, page 2-7-7], unless such action is necessary to–

- remove injured persons or animals or to confirm fatalities; or
- protect the aircraft and contents from further damage; or
- disconnect or de-activate a CVR, FDR, or ELB.

Delegation of authority to remove damaged glider in certain cases.

Where no injury has been sustained, and where there is no suspicion of any aircraft malfunction or criminal activity, the relevant CFI, or contest director of a regional or national contest, or National Operations Officer, or Regional Operations Officer may authorise the removal or repair of a damaged glider.

The exercise of such authority does not release the pilot-in-command or the operator from their responsibility to notify the NZGA or CAA of the accident discussed.

[PART I ENDS HERE]

PART II – AIRMANSHIP AND NAVIGATION

A. NAVIGATION

AERONAUTICAL CHARTS AND MAP READING.

Aeronautical charts are important for glider pilots on cross-country flights, and we will now look at some of their features—

Map scales.

The most recommended charts have a scale of either—

1:500,000, in which 1" = approx. 8 stat. miles
 or
1:250,000, in which 1" = approx. 4 stat. miles.

[WRITE THESE DOWN AND LEARN THEM!]

Map Projection. [PSN, page 12]

The type of map projection most widely used and preferred by pilot navigators is called “Lambert's Conformal Conic Projection”.

[DISCUSS THE CHIEF FEATURES OF THIS TYPE OF MAP PROJECTION, WHICH EXPLAINS WHY IT IS PREFERRED]

Signs and symbols (Legends). [PSN, page 12]

[REFER TO PSN AND TO SAMPLE CHARTS FOR EXAMPLES]

Map reading in the air.

The correct sequence for airborne map reading technique is to read from the map to the ground, and then refer back to the map again. Look for features on the ground, and positively identify them by cross-references to other features on the ground and on the map.

Correct orientation of the map is helpful – i.e. align the view on the map with the view on the ground.

A useful device for judging distances is described on page 13 of the PSN. A feature on the ground observed from 5000 feet at an angle of 45° will be approximately 1 mile distant from the point on the ground directly below you.

NAVIGATION GENERALLY [PSN, PAGE 14]**Great Circle.**

A great circle is any line on the earth's surface whose plane passes through the centre of the earth. The line is called a great circle arc, and is the shortest distance between any two points on the earth's surface.

[DISTINGUISH A SMALL CIRCLE ARC FROM A GREAT CIRCLE ARC]

Meridians of longitude [PSN, page 14]

A meridian of longitude is one half of a great circle arc joining the poles.

They run true north and south.

Every place on earth has a meridian of longitude running through it.

Parallels of latitude [PSN, page 14]

A parallel of latitude is a small circle on the earth's surface whose plane is at right angles to the earth's axis and is parallel to the equator. (The equator itself, of course, is a great circle).

Parallels of latitude run true East and West.

Every place on earth has a parallel of latitude running through it.

Geographical position.

Since every place on earth has a meridian of longitude and a parallel of latitude passing through it, the geographical position of that place can be defined in terms of the point where these two lines intersect; i.e. in terms of latitude and longitude. By international convention, latitude is always given first.

Both latitude and longitude are measured in degrees (°), minutes (') and seconds (").

Latitude is measured in degrees, minutes and seconds North or South of the equator.

Longitude is measured in degrees, minutes and seconds East or West of the prime meridian (or Greenwich meridian).

[GIVE PRACTICAL EXERCISE AT THIS POINT IN FIXING A GEOGRAPHICAL POSITION FROM CHARTS]

The nautical mile.

The nautical mile is an important unit of distance in navigation.

It is defined in terms of latitude–

1' of latitude = 1 Nm, and therefore 1° of latitude = 60 Nm

DIRECTION ON THE EARTH'S SURFACE.

True direction.

True north or South from any point lies along the meridian passing through that point; i.e. it is the direction of the geographical north or south poles from that point.

True east and west lie at right angles to the meridians at any point and run parallel to the direction of the earth's rotation.

North, south east and west are known as the **cardinal points** of the compass. The points in between are known as **quadrantal points**.

Bearing (direction).

Bearing or direction is measured in degrees with respect to north on a compass "rose" (a circle divided into 360°)

A protractor measures bearings of the compass for navigational purposes.

The bearing or direction of a point is always given in three figures, e.g. 010, 008, or 270. Degrees of direction may also be divided further into minutes and seconds, just as were degrees of latitude and longitude.

Magnetic direction.

The earth's magnetic field has poles like any other magnet. These are called the magnetic north and magnetic south poles.

However, these magnetic poles are not aligned with the geographic poles. Their position also alters slightly each year; they are slowly rotating around the geographic poles.

A compass needle, when suspended freely, will align itself with the lines of the earth's magnetic field. It will be pointing magnetic north and south, and this phenomenon enables us to use the magnetic compass in navigation.

The direction of the compass needle is the direction of the magnetic meridian of the place where the compass is. Because the compass points in a different direction to the true meridian, there will always be an angular difference between the true and the magnetic meridians passing through any point.

We call this angular difference **variation**.

Variation.

Variation is termed "East" or "positive" (+) if magnetic north is east of true north, and "west" or "negative" (-) if magnetic north is west of true north.

Variation changes from place to place on the earth's surface, as well as changing gradually in amount from year to year. At present, variation in New Zealand is approximately 20° east.

Variation on maps.

There are several different methods of indicating variation on maps: e.g.–

- (i) Marginal notes
- (ii) Compass pointers
- (iii) Isogonals

[PSN, page 16]

An **isogonal** is a line joining **points of equal variation** on the earth's surface.

Conversion of true direction to magnetic and vice versa.

In New Zealand, variation is always east, therefore, magnetic bearing will always be less than true bearing in terms of degrees. [PSN, pages 16, AND EXPLAIN BY REFERENCE TO THE DIAGRAM THERE] – This is very convenient because we can use this handy little formula to remind us of which way to do conversions–

VARIATION EAST – MAGNETIC LEAST

VARIATION WEST – MAGNETIC BEST

N.B. – LEARN THIS WELL!

Deviation.

Extraneous factors in an aircraft may cause a compass needle to go out of alignment, as it is a magnet which may be influenced or deflected from a proper reading by metal objects or electrical circuits in the aircraft itself. This is why an aircraft compass must be "swung" to determine the amount of difference (if any) between the correct magnetic reading and what the compass is actually reading in the aircraft on various headings.

Compass “swinging”

[EXPLAIN THE PROCESS OF "SWINGING" AN AIRCRAFT COMPASS]

As a result of a compass "swing", a compass card, or deviation card is prepared for that particular aircraft.

[PSN, PAGE 17 FOR AN EXAMPLE OF A **COMPASS CARD**]

We call these differences between what the compass is actually reading, and what it should be reading **deviation**, i.e. the amount it **deviates** from what it should be reading.

Like variation, deviation is termed "East" or "positive" (+) if the compass heading is east of magnetic north, and "west" or "negative" (-) if the compass heading is west of magnetic north.

Again we have a convenient conversion formula to convert compass headings to magnetic headings.

DEVIATION EAST – COMPASS LEAST

DEVIATION WEST – COMPASS BEST

N.B. – LEARN THIS WELL!

[WORK THROUGH THE CONVERSION EXAMPLE ON pages 17 PSN]

You are not required to be familiar with compass errors for the exam, but there is a note on compass errors on page 20 of the PSN if anyone is interested.

MEASUREMENT OF DISTANCE AND SPEED.

(a) Distance.

Some conversions you should memorise are–

- (i) 1 statute mile = 5280 feet.
- (ii) 1 nautical mile = 6080 feet.
- (iii) 1 kilometre = 3280 feet.

A useful guide for mental conversion from nautical miles to statute miles is–

66 nautical miles = 76 statute miles.

[DO EXERCISE OF CALCULATING DISTANCES FROM MATAMATA TO RIDGE]

(b) Speed.

Speed may either be expressed as (i) statute miles per hour (mph) or (ii) nautical miles per hour (knot).

The knot is as measure of speed, **not** distance.

It is more convenient to work in knots in air navigation because–

- (i) It is easy to find on the latitude scale on maps,
- (ii) Airspeed indicators are calibrated in knots,
- (iii) Wind velocities are given in knots.

TRACK AND COURSE CALCULATIONS.

Actual calculations of track and course will not be required for the exam. You will also not need to concern yourselves with polar curves, speed calculations, or triangles of velocities, but you must be familiar with the following terms and concepts–

Track.

The track of an aircraft is its path over the ground. The required track or course is the track you wish to follow, and the track made good is the actual path. Ideally, of course, the two should coincide.

[PSN, page 18 for a graphic illustration of the difference between course and track made good]

Drift.

Drift is the angular difference between heading and track. It is always measured from heading to track. Drift is termed port or starboard, depending on whether it is to the left or right of heading.

Wind velocity.

Wind velocity involves two components, that of wind direction and speed. The direction portion is always given as the direction from which the wind is blowing. It is given in three digits representing the direction in degrees, and the speed portion is given in two digits representing knots, with a "stroke" separating the two components – e.g. 030/20.

[CAUTION RE THE DIFFERENCE BETWEEN ORAL AND WRITTEN WIND DIRECTIONS SUPPLIED BY ATS UNITS]

Bearing.

Bearing simply means direction from one place to another.

ELEMENTARY NAVIGATION IN CROSS-COUNTRY GLIDING.

No further detail on navigation is required for the purposes of the exam, but you should be aware of what is involved from the navigation stand-point in every successful planned cross-country glider flight. Pilots flying for a badge flight or a competition task will plot a course on their map. They will be aware of any drift en route and will make any necessary adjustments. If some drift is present, it will be necessary to cruise between thermals at some angle to the desired track (course), obviously to some thermals upwind if possible.

It is extremely unusual for gliders to fly by a compass heading alone. Usually visual checks will be made with the ground and maps to ensure that the desired course is being followed as faithfully as possible.

You are not required to know about calculating speeds-to-fly or polar curves as described on pages 18-19 of the manual for the exam, but any pilot wishing to advance to cross-country or competition level should begin to familiarise themselves with these concepts.

[Any instructor will be able to recommend further reading to anyone interested]

B. ASPECTS OF AIRMANSHIP

BASIC RULES OF THE AIR

We have already looked at the following rules and procedures, and you should by now be quite familiar with them—

- (i) The give-way rules
- (ii) Ridge-flying rules
- (iii) Thermalling rules
- (iv) Formation flying rules

We have also looked at **emergency aerotow signals between tug and glider**. In addition to these rules there are certain other procedures that must be observed whilst on aerotow and which you must know and learn for the exam. They crop up in various forms in various papers.

They are:

BASIC EMERGENCY PROCEDURES.

(A) Action in the event of finding yourself too high on tow.

If you find yourself much too high in relation to the tow plane, you descend by using airbrakes, and not by lowering the nose or by side-slip.

(B) Action in the event of being unable to release from tow.

If you are unable to release from tow, you must first signal the tow pilot.

[DISCUSS THE CORRECT SIGNAL] [DISCUSS WHAT ACTION THE TOW PILOT AND GLIDER PILOT SHOULD TAKE]

You are not sure whether you still have some or all of the rope still attached. You should operate the release lever several times after the tow pilot has released you, and return to base immediately. You must prepare to land as soon as possible. Do not attempt to extend the flight unnecessarily (you must assume that you may still have some rope attached). Make a higher than normal approach to land further up the field than normal.

(C) Action in the event of encountering severe turbulence on tow

If you encounter sufficient turbulence on tow to cause you to lose sight of the tow plane, or if you lose sight of the tow plane for any reason, you must release immediately. Do not wait for the tow-plane to reappear, or try to regain position on tow.

FURTHER ASPECTS OF AIRMANSHIP.

You must be Thoroughly familiar with the following–

Spin Recovery.

The correct recovery action for recovery from a full spin is to–

APPLY FULL OPPOSITE RUDDER, PAUSE AND EASE THE STICK CENTRALLY FORWARD (AILERONS NEUTRAL) UNTIL THE ROTATION STOPS, THEN EASE OUT OF ANY RESULTING DIVE INTO NORMAL FLYING ATTITUDE AND AIRSPEED.

- Note:
1. The pause is not always necessary with some gliders, but the above procedure will work with most gliders and should be followed.
 2. The ailerons should be held neutral throughout the whole recovery procedure as "opposite" aileron may delay or prevent the unstalling of the wings. "In-spin" aileron also will do nothing to aid recovery and may delay it.

Recovery from a wing drop in a slow turn.

If a wing drops in a slow turn, you should ease the stick centrally forward (ailerons neutral) without delay and apply **opposite rudder as required** to correct any yaw. If a full spin develops, then apply full opposite rudder and proceed with full spin recovery action. If in doubt as to whether condition is a full spin or merely an incipient spin, assume a full spin and act accordingly.

Note that if there is no yaw present, NO “opposite rudder” is required. In fact any unnecessary rudder will not help a speedy recovery.

Recovery from a steep turn with speed beginning to rapidly increase (spiral dive situation).

This is the beginning of a “spiral Dive” situation. The correct recovery from a “spiral dive” is to, **IN THE FOLLOWING ORDER**–

1. relax any back-pressure, or “pull”
2. reduce the bank
3. ease out of the dive by reducing the speed.

[Discuss what can happen if this correct sequence is not followed.]

Cloud flying with speed beginning to rapidly increase.

Open the dive brakes.

DO NOT ease back on the stick **[WHY NOT?]**

DO NOT use rudder to try and instigate a spin **[WHY NOT?]**

Paddock selection and outlandings.

Wind direction may be the primary consideration in choice of landing direction on a flat surface!

The “The seven S’s” – a good guide to what to look for.

Size	There should be sufficient room for a landing in the desired direction. Look for the longest possible landing site that faces into wind.
Shape	Do not limit your selection to sites that resemble a rectangular runway. The perfect shape is in fact a circle, as it allows approaches to be made from many different directions over obstacles and ensures a landing into wind. Bear in mind that it may be beneficial to land diagonally across sites that are rectangular.
Slope	If a site has a perceptible slope from the air then it is sufficient to indicate that you should only attempt an uphill landing. A downhill landing may well result in the field slope being greater than the landing profile of the glider, and will almost certainly result in a longer ground roll. It can be difficult to judge the gradient of a slope from altitude. Rivers and creeks running downhill may give you some clues.

- Surface** Look for flat, open terrain, preferably smooth, grassed, with any ditches, fences etc clearly obvious. The best is a paddock that has been cut for hay. A cultivated paddock ensures that obstacles can be seen and the landing roll will be short. Standing hay and crops should be avoided, as should paddocks with stones or stumps. Standing pasture may have electric fences through it that are almost invisible from the air. Airstrips are excellent but usually slope markedly one way, leaving an uphill landing as the only option..
- Stock** Stock may be considered under “Surface” above. Try to avoid landing sites where stock are present as they not only present a hazard but cattle can damage the glider if you have to leave it.
- Surroundings** Where possible, it is advisable to select a landing site that allows a good unimpeded final approach, clear of tall trees, power lines, buildings, an even high fences. Look also for any obstacles upwind of the area (wind gradient considerations).
- Sun** Sun can be a problem with landings late in the day. An approach in the direction of the sun may blind the pilot on final so try to avoid this if possible.

[Exercise – in the light of all these considerations, describe the ideal landing area]

Selection height

You should at all times make sure that you can reach a landable area with sufficient height left to choose a paddock and execute a proper circuit of it prior to landing.

[DISCUSS THE REASONS FOR REQUIRING A PROPER CIRCUIT IN ALL CASES]

Do not start looking for paddocks at any set height, just obey the above rule at all times.

Sloping paddock

Always land uphill into a sloping paddock if you have to land in one. This rule applies always, **regardless of wind direction!**

If various choices of paddock are available

If a choice of paddocks of a suitable size is available, then obviously go for the best possible, e.g. if the choice is between paddocks containing–

- (a) Golden crops
- (b) Grass with cattle in one corner
- (c) Rough ploughed surface

[Which one would you choose? – According to one of the exam papers, (b) is the desired choice.]

Landing commitment

Assume you are at 200 feet AGL on base leg for a strange paddock on a cross-country flight and you encounter a thermal. [What should you do?]

You should ignore it, even if there are large paddocks downwind of your position.

Landing procedure in a strange paddock.

Q. Should the glider be–

- (i) "flown on" to the ground?
- (ii) Landed with the brakes closed?
- (iii) Landed with a normal "hold-off" and a "two-point" touch-down?

Landing considerations generally.

The following considerations apply to any landing, whether on the home airfield or in a paddock–

Strong wind conditions

The normal approach speed of the glider for calm conditions should be increased by at least 50% of the estimated wind speed.

[DISCUSS HOW WIND STRENGTH AND DIRECTION MAY BE ESTIMATED]

[Discuss our usual formula for fixing best circuit/approach speed]

Wind gradient – [PSN, pages 58 and 72]

[REFER TO THESE pages AND DISCUSS THE DEFINITION AND EFFECTS OF WIND GRADIENT]

When should one expect a wind gradient, and why? In **strong wind conditions**, and in the **lee of upwind obstructions**.

A wind gradient can occur at any height in a circuit or near the round, and can affect the glider in slow turns as well as on a landing approach.

Action to counter the effects of a wind gradient -

INCREASE SPEED BY LOWERING THE NOSE, AND AT THE SAME TIME CLOSE THE AIRBRAKES PROMPTLY AS REQUIRED.

Cross-wind landings

Landing in a cross-wind requires a special technique. The "crab" method of approach should be adopted, with the wings level and the nose pointing into wind to counter drift. Just prior to touch-down the glider should be "kicked" straight along the landing path with rudder to remove the sideways "drift" of the glider. As soon as drift has been removed, the glider should touch down and be kept firmly on the ground to avoid any further sideways drift. A normal "hold-off" landing is not advisable in a cross-wind as there may well be further drift. Side-loads on landing can damage undercarriages, tail-skids, and even fuselages. They are to be avoided if at all possible.

[DISCUSS THE TECHNIQUE FOR REMOVING DRIFT JUST PRIOR TO TOUCH-DOWN]

“Downwind” landings.

“Downwind” landings are to be avoided. [WHY?]

The main worry with “downwind” landings is that the glider’s controls always lose their effectiveness during the ground roll on landing as airspeed slows as the glider slows down. In the case of a “downwind” landing this loss of effectiveness occurs at a higher ground speed, and the risk of an inadvertent ground loop or damaging side loads on the aircraft is much greater.

Winch Launch signals and procedures.

- Q. If the glider’s speed is rapidly approaching the maximum winch placard speed, what should be done?
- A. **You must release immediately** after lowering the nose slightly. The lowering of the nose is to ease the tension on the wire prior to release.

If the speed is becoming too fast, and you wish the winch driver to slow down – What is the signal?

[YAW THE GLIDER FROM SIDE TO SIDE WITH THE RUDDER]

Water on the wings!

What is the effect of water on the wings, say for instance if you have just flown through some rain?

1. You should expect a higher than normal rate of descent because the water is creating extra drag, and preventing the normal flow over the wing which generates lift.
2. You should also expect an increased stall speed due to water disturbing the normal airflow over the wing.

ASI failure.

You have taken off on aerotow and at about 200 feet AGL you realize that your ASI is not working – What do you do?

You continue the tow to a sufficient height for a full circuit, then make a normal approach and landing, paying particular attention to the glider's attitude. You fly by attitude as you would for a no- instrument circuit.

Rough L/D calculation.

Assume you have a glider with a "best L/D" (glide ratio) of 30:1)

Which of the following three answers is the closest to the approximate distance it will cover in still air for each 1000' of height loss?–

- (i) 18 kilometers
- (ii) 4.5 Kilometres
- (iii) 9 Kilometres

[PART II ENDS HERE]

PART III — PRINCIPLES OF FLIGHT, GLIDER CONSTRUCTION AND LIMITATIONS

A. PRINCIPLES OF FLIGHT

SOME USEFUL DEFINITIONS.

Before discussing the principles of flight we need to know and understand the definitions appearing on page 24 of the PSN.

[EXPLAIN THESE DEFINITIONS, USING DIAGRAMS IF NECESSARY]

What then enables us to commit aviation in a machine that is heavier than air such as a glider or an aeroplane. Why does a glider behave differently in the air than a 500 kg brick?

To enable us to understand how flight is possible we need to explore a number of concepts—

AIR AS A FLUID.

Air is a fluid, and therefore it has certain properties and behaves in a certain manner just like other fluids. We will examine the composition of air more fully in the next part of the course (meteorology), but for the moment we will accept that air is a fluid and a gas, and that it behaves accordingly.

One of the most important properties of air concerning flight is its viscosity or thickness. It has a tendency to cling to anything that moves through it to some extent, just like oil. This viscosity of the air goes a long way towards explaining the generation of lift on a wing moving through the air, as we will shortly see.

BRIEF INTRODUCTION TO WEIGHT, LIFT AND DRAG.

[Throughout the following discussion it may help to think of a "force" as a "pull".]

Weight.

Weight is a force opposing lift. It acts vertically downwards (towards the centre of the earth), and it acts through the centre of gravity of an object. Lift must counter weight to some extent to make flight possible. Weight is an "enemy" of lift.

Drag.

An object moving through a fluid (such as air) will obviously encounter some resistance from that fluid. This resistance acts on the object in the opposite

direction to its motion and will therefore counter this motion to some extent. We call this resistance drag. Drag, like weight, is also an "enemy" of lift, but not quite to the same extent as weight. The weight of a glider is the main "opposing" force that must be overcome by lift for flight to be possible.

Lift.

Lift is the force we need to make flight possible.

Lift must counter the weight of the glider by providing a force with a vertically upwards component in normal flight. (Remember that weight acts vertically downwards, therefore lift must act vertically upwards). Remember, lift must counter drag as well as weight, though not to the same extent.

If it were not for this force called lift, then a glider would drop under the pull of gravity with the same acceleration as any other mass, e.g. a 500 kg brick.

In a glider, lift never completely overcomes weight, at least not in still air. We cannot therefore maintain steady horizontal flight in still air. Because of the very nature of gliders, their flight path always slopes downwards in still air. The glider will be slowly descending like an aerial toboggan. Every glider has a still-air sink rate for various speeds built in to its design. This sink rate is a considerable improvement on that of our 500 kg brick, and is due to this force we call lift.

THE FORCES ACTING ON A GLIDER IN STEADY STRAIGHT AND LEVEL FLIGHT.

[Remember – think of a "force" as a "pull".]

In considering the principles of flight we will be referring to balanced and unbalanced forces acting on a body such as a glider (or its pilot) in flight. These terms have a special meaning in physics and aerodynamics, and in discussing them it may be helpful if you think of a complete "balancing" of one force by another as a "cancelling out" or complete "countering" of that force, and a "partial balancing" as only a partial countering of the force. An example of a force which usually imposes only a partial countering of other forces is friction, and a similar "partially countering" force in aerodynamics is drag. Lift can be another, and often is with gliders!

To understand the forces on a glider flying at a steady speed in a straight line you will have to accept as gospel Newton's third law of motion.

This "law" states basically that a body at rest, OR a body moving at a steady speed in a straight line, will continue in that state until an unbalanced force acts upon it.

Because a body travelling at a steady speed in a straight line will continue in that state unless upset, the body and the forces acting on it are said to be in equilibrium. The forces are balanced, just as if it was at rest. The body is neither accelerating nor decelerating, and it is not deviating from its straight-line flight path. It will not alter its speed or direction unless an unbalanced

force is applied to it. Any such "changing" force is called an accelerating force, or simply, an acceleration. In normal language we refer to a change of speed as an acceleration, but in physics (and aerodynamics), a change of direction of motion is just as much an acceleration as a change of speed, and requires an unbalanced force to produce it in just the same way.

When talking about forces acting on a body, we must be careful to consider all of the forces acting on it. Some of the forces acting may be balanced (cancelled out) by others, or may only be partially balanced (partly countered) by others. Remember, just to recap, all the forces can only be said to be balanced (or in equilibrium) if the body is at rest, or is travelling in a steady speed in a straight line. If any of the forces do not balance, then we see a change in the "at rest" or "steady speed/straight line" state of the body. Remember also that we call the force producing any such change (in either speed or direction) an acceleration.

[EXAMINE AND DISCUSS THE DIAGRAM ON pages 27, PSN OF THE FORCES ACTING ON AN AIRCRAFT IN STRAIGHT AND LEVEL FLIGHT]

We will examine the forces on a glider in other modes of flight shortly, but first we look more closely at some of the elementary concepts with which we must become familiar.

LIFT.

What "causes" or generates lift in an aircraft?

The wing of an aircraft is by far the most important part of an aircraft producing lift, so much of our discussion concerning lift will centre around wings and wing sections (aerofoil sections).

Lift is generated by the movement of the airflow over the surfaces of the wings of an aircraft.

The earlier experimenters in flight originally thought that flat plates drawn through the air at a small angle would serve as wings.

[DEMONSTRATE – SOME LIFT CAN BE PRODUCED, BUT ALSO MUCH DRAG]

These early experimenters were right to some extent. Consider the example of model balsa gliders with plain flat wings and plasticine noses that many of you may have tried at some time or another. They had some glide performance at least.

However, they soon discovered that much better and more efficient wings could be made by shaping the surfaces into curves instead of making them flat. These curved surfaces produced a much larger lifting effect for a much smaller drag. We call these shapes "aerofoils", and we call their cross-sections "aerofoil sections".

The wing cross-section, or aerofoil section, is shaped in a particular way to direct the airflow in the desired manner to produce lift.

[PSN, PAGES 25 & 26 FOR EXAMPLES OF AEROFOIL SECTION AND THE AIRFLOW OVER THEM]

Due to the camber or shape of the aerofoil, the airflow over the top surface is deflected through a greater distance than that which flows across the bottom surface of the wing. This has the effect of making the air over the top of the wing travel faster than the air underneath.

[RECAP ON THE VISCOSITY OF THE AIR, AND DISCUSS THE VENTURI EFFECT TO EXPLAIN WHY THE AIR OVER THE TOP IS "FORCED" TO GO FASTER THAN THAT UNDERNEATH THE WING]

Bernoulli's theorem.

A chap called Bernoulli discovered that there is a relationship between the velocity of a fluid (e.g. air), and its pressure.

[PAGE 24 OF THE PSN FOR THE EXPLANATION OF THE THEOREM AND THE FORMULA THAT GOES WITH IT]

You are not required to learn it for the exam, but it is all there for reference if you need it. The important thing that you do need to know and understand about it all is that, if the speed of a fluid (such as air) increases, then its pressure decreases!

It is this pressure difference between the top and bottom surfaces of a wing which produces virtually all of the lift from an aerofoil section. I say "virtually" because there is a small amount produced by the "deflection" or "flat plate" effect of the air striking the lower surface of the wing. [Diagram on page 26, PSN]

Remember, most of the lift comes from the top surface of the wing, and is due to the pressure difference between the two surfaces induced by the airflow, which is influenced by the shape or camber of the wing section!

The centre of pressure.

You must have some knowledge of the centre of pressure for the exam.

[PSN, pages 26 FOR AN EXPLANATION OF CENTRE OF PRESSURE]

The main points to note are what the centre of pressure is, and that its position varies along the wing chord depending on the angle of attack; e.g.–

- (i) It moves forward as the angle of attack increases (up to the point of stall, when it moves rapidly back).
- (ii) It moves backwards (towards the trailing edge) as the angle of attack decreases.

Factors affecting the amount of lift generated.

The amount of lift being generated at any time depends on—

1. The speed of the airflow over the wing.
2. The angle of attack.
3. The amount of drag present.
4. The weight of the aircraft.
5. The Camber of the wing.

Remember, the angle of attack is the angle between the chord of the aerofoil section and the direction of the relative airflow. The relative airflow is the striking of the air against the wing, or if you like, the striking of the air by the wing.

[TO pages 26 & 34 PSN FOR DIAGRAMS SHOWING ANGLE OF ATTACK]

DRAG.

Now for a closer look at drag.

The Lift/drag (L/D) ratio.

For best glide performance, the drag should be as small as possible compared to the lift. The resultant force (combined effect) of lift and drag can be shown by vector diagrams (e.g. pages 26 and 27 PSN). It should be as near to a right angle to the direction of motion as possible. The ratio of the lift to the drag (L/D) is a measure of glider performance. It is also the glide angle of the glider in still air – e.g. 36:1.

The relationship of drag to speed.

Both lift and drag vary in proportion to the square of the speed of the airflow.

This is just a fancy way of stating that, if the speed of the airflow is doubled, then both the lift and the drag will generally not increase by only a factor of two (like the speed), but by a factor of four – i.e. the lift and the drag will each be four times their respective original values if the airspeed is merely doubled.

The relationship of drag to angle of attack.

Drag will increase generally with an increase in the angle of attack. Lift will also increase with an increase in the angle of attack, but the point will be reached where the increased drag overcomes any lift advantage or the aircraft stalls. (Normally a glider will stall at an angle of attack of about 15°.)

Profile drag (form drag).

The kind of drag we have been looking at so far (i.e.. the kind that varies with the square of the speed) is called profile drag, or form drag. It is a function of the design of the aircraft and the resistance of the air.

Induced drag.

Induced drag is a different type of drag. It is induced by the pilot. It varies inversely with the square of the speed – i.e. if the speed is halved, then the induced drag is quadrupled.

The slower the speed, the more the induced drag. Induced drag is greatest when the angle of attack is high.

Induced drag is part of the energy which produces wing tip vortices and a certain amount of down-wash.

[PSN, PAGE 36, FOR AN EXPLANATION OF INDUCED DRAG]

The important thing to remember for the exam about induced drag is that it is the type of drag associated with high angles of attack (slower airspeeds), and that it increases as the angle of attack increases.

EFFECT OF WEIGHT VARIATIONS ON GLIDER PERFORMANCE.

An increase in weight will not affect the best glide angle of the glider, but will affect the speed at which this best glide can occur. The effect of an increase in weight, e.g. a heavier pilot, more ballast weights, or the addition of water ballast, is to increase the speed at which a given glide ratio occurs. E.g. the best L/D of a glider may be specified as 36:1 at 50 kts unballasted, whereas with full water ballast on board, this may be achieved at say 60 kts, but will still be 36:1.

[DISCUSS WHY THIS SHOULD BE SO]**[REFER TO PSN, PAGE 36 FOR AN EXPLANATION]**

A heavier glider will have a higher sink rate, particularly at the lower and higher ends of its speed range, and this is why, when thermal conditions get weaker, gliders will jettison some or all of their water ballast to reduce their sink rate (and thus, of course improve their climb rate).

N.B. - An increase in weight will also result in an increase in the stalling speed of the glider.

[DISCUSS WHY THIS SHOULD BE SO]**[PSN, PAGE 36 FOR EXPLANATION OF THE EFFECT OF INCREASED WEIGHT]**

AILERON DRAG AND ADVERSE YAW.

Generally, a down-going aileron will "bite" into the airflow more than an up-going one due to the camber or shape of the wing to which it is attached. The down-going aileron therefore creates more drag, and this results in a yawing movement which is opposite to the desired direction of turn! Hence the term "adverse yaw".

One method used to minimise the effect of adverse yaw is to use differential ailerons that are geared differently so that the up-going one moves further than the down-going one to balance the drag out a bit.

Aileron drag is more marked in gliders than in other types of aircraft.

[DISCUSS WHY THIS SHOULD BE SO]

Aileron drag will always be present to some extent whenever the ailerons are used, and this is the reason why it is necessary to always fly with the stick and rudder co-ordinated together.

Adverse yaw is particularly pronounced when rolling in and out of turns. It is not so evident on aerotow. [DISCUSS WHY NOT]

STABILITY – AND THE THREE AXES OF MOVEMENT.

[PSN, pages 30 FOR A DISCUSSION OF THE THREE FIXED AXES OF MOVEMENT AND OF STABILITY]

[DISCUSS ROLLING, PITCHING, AND YAWING, AND ABOUT WHICH AXES THEY OCCUR]

Longitudinal stability (pitch stability).

The elevator and tailplane provide balance and stability at a desired speed. The tailplane and elevator has an angle of attack and an airflow of its own. It is well behind the C. of G. and therefore provides a large turning moment about the lateral axis for any force acting on it. Longitudinal stability decreases as the C. of G. moves rearward. This is because there is then a shorter turning moment operating.

It is largely for this reason that you must never fly an aircraft that is "tail-heavy" beyond its allowable limits. Apart from the severe pitch control problems that could result, effective stall/spin recovery would be greatly reduced or impossible. Hence the extreme importance of proper ballasting in the cockpit of a glider!

Lateral stability (roll stability).

Dihedral, sweep-back, or both will tend to correct any bank once an aircraft starts to slip sideways towards a lowering wing – i.e. there will be a slight

tendency for the wings to be levelled. This assists in maintaining lateral stability.

Directional stability (yaw stability).

Yaw stability is of course mainly provided by the tail fin and fuselage. The "weathercock" effect of the fin and fuselage tends to counter any "slip" and directional problems.

FORCES ACTING ON A GLIDER IN A TURN. [PSN, pages 31]

For a steady, accurate turn, most of the forces on the glider will be balanced, but one will be predominant (unbalanced). [Which one?]

What causes this unbalanced force to turn the glider?

Is there a force opposing the turning force? What is it called?

When the glider is banked, the lift, which acts almost vertically in straight flight, becomes inclined and acquires a sideways (horizontal) component which provides the required turning force.

[DEMONSTRATE WITH MODEL]

The horizontal turning force is opposed by centrifugal force, but obviously overcomes it (or the glider would not turn).

Since the main lift force of the glider has been tilted from the vertical, some vertical component of lift has been lost. This lift must be replaced if it is to continue to counter the weight of the glider to the same extent as it did in straight and level flight. This is normally done by increasing the angle of attack.

Increasing the angle of attack in a turn will have the effect of tightening the turn and increasing the "weight-like" forces on the pilot and glider. These forces are called "g" forces; 1"g" being 1 x the value of the force of gravity. A body subjected to the pull of gravity only is undergoing a force of 1"g".

[Which direction do these "g" forces act in?]

The "g" forces acting on the pilot (and the glider) are the resultant (combined effect) of the centrifugal force and weight.

They act directly down the glider's vertical axis in a properly executed turn, and it is this "g" force that keeps the "ball" in the turn and slip indicator in the centre, and which gives the pilot the sensation of increased weight pushing down into the seat. The forces felt are a reaction to the accelerating force causing the glider to turn.

[REFER TO THE ANALOGY OF A PERSON IN AN ELEVATOR WITH A HEAVY BRIEFCASE TO EXPLAIN WHY AN ACCELERATION IN ONE

DIRECTION IS FELT AS A FORCE IN THE OPPOSITE DIRECTION. BEING PUSHED BACK INTO ONE'S SEAT IN A POWERFUL AIRCRAFT TAKING OFF IS ANOTHER EXAMPLE]

The amount of "g" force needed to maintain a steady turn will depend on the angle of bank in the turn.

If the pilot does not apply ("pull") sufficient "g" then the vertical component of lift will not be sufficient to keep the glider from descending into a spiral dive situation. If the pilot pulls too much "g", then the glider will slow up, and may eventually stall. Note that in a turn the glider may stall at higher airspeeds than normal.

[DISCUSS WHY THIS SHOULD BE SO]

[TO THE DIAGRAM ON pages 31 PSN FOR VARIOUS "G" LOADINGS FOR DIFFERENT BANK ANGLES]

This diagram also shows that the stalling speed increases in proportion to the square root of the "g" loading.

For instance, a turn of 60° of bank requires 2 G's of "pull" to maintain it, and in such a turn the stalling speed is increased above the normal level-flight stalling speed by a factor of 1.4, which of course is the square root of 2 (number of "g's" needed).

[DISCUSS THE 75° BANK SITUATION BY WAY OF FURTHER EXAMPLE]

In a steady turn, the lower wing is travelling in a slightly smaller radius, and is therefore travelling slightly slower than the upper wing. The upper wing is therefore generating more lift than the lower wing, and there is a tendency for the bank to steadily increase. A little opposite aileron is therefore usually required to check this tendency.

Note that, as well as creating more lift, the outer (faster) wing is also creating more drag. A little rudder is also required to counter the yaw due to this extra drag. [WHICH RUDDER DO WE NEED?]

THE SPIN [PSN, PAGES 32]

The conditions necessary for the development of a spin.

Both a *stall* and a *yaw* are required.

If a wing stalls and drops, then a condition called autorotation (spin) may develop. The spin is a very complex motion involving yawing, rolling, and pitching movements. It is one of the most difficult aircraft motions to analyse.

Recovery action from a spin.

Some aircraft may recover from a spin virtually unaided by the pilot. Others may require a definite sequence of control movements. Many aircraft are reluctant to spin at all.

The standard recovery procedure (which we have already covered, and is detailed on page 34, PSN) is recommended for most gliders.

[IT MUST BE LEARNED THOROUGHLY, BOTH FOR THE EXAM AND FOR YOUR GENERAL FLYING, AND YOU SHOULD PRACTISE IT OFTEN IN THE AIR]

It is so important that I give it to you again!

The correct recovery action for recovery from a full spin is to–

APPLY FULL OPPOSITE RUDDER, PAUSE AND EASE THE STICK CENTRALLY FORWARD (AILERONS NEUTRAL) UNTIL THE ROTATION STOPS, THEN EASE OUT OF ANY RESULTING DIVE INTO NORMAL FLYING ATTITUDE AND AIRSPEED.

Effect of weight and balance on spin recovery.

Aircraft tend to spin about their c. of g. The position of the c. of g. has a marked effect on the spin recovery capability of an aircraft. A c. of g. that is too far aft will have a shorter "tail arm", and therefore reduced yaw damping from the fin and rudder. This could lead to a flat spin from which recovery could be extremely difficult, if not impossible. This is an excellent reason for not flying a "tail-heavy" aircraft. Always ensure that there is sufficient weight of pilot and ballast in the front cockpit.

RECOVERY OF A STALLED WING. [PSN, PAGES 33]

The use of aileron to pick up a stalled wing will not work and should not be attempted. The reason for this is that a down-going aileron will effectively increase the angle of attack of the wing and therefore will accentuate its stalled condition. Also, the down-going aileron will increase the drag on that wing, thereby resulting in further loss of lift from it.

WASHOUT [PSN, PAGES 33]

Washout is a slight twist built into the wing design so that the tip of the wing is at a slightly lesser angle of incidence than the rest of the wing. This means that the inner wing will generally stall before the outer wing, giving the pilot better warning of the onset of the stall and enabling better recovery. The pilot can usually take recovery action before the tips stall, and recovery action is quicker and easier than if the whole wing was to stall at once.

FLAPS – EFFECT OF. [PSN, PAGES 34]

Flaps on an aircraft will–

- (i) Increase the lift available at certain airspeeds
- (ii) Reduce the stalling speed
- (iii) Increase the drag, and therefore enable a steeper landing approach to be made.

With flaps therefore, the landing approach can be slower and steeper, and often with better visibility due to a nose-down pitch change on some gliders.

AERODYNAMIC BALANCING. [PSN, PAGE 29]

Aerodynamic balances are found on control surfaces, and are designed to make the controls lighter for the pilot to operate, and to give the desired blend of stability and control.

[pages 29 FOR DIAGRAMS AND EXPLANATION AND DISCUSS]

MASS BALANCING. [PSN PAGE 37]

Mass balancing is used to avoid **flutter!**

[page 37 PSN FOR EXPLANATION AND DIAGRAMS]

AIRSPEED INDICATORS.

You are required to have a very basic knowledge of what an airspeed indicator is and how it functions.

[page 38 PSN FOR A DIAGRAM OF AN AIRSPEED INDICATOR]

An airspeed indicator measures the dynamic pressure of the air flow, i.e. the pressure it "feels" due to the aircraft's motion through the air. It does this very simply as the diagram shows.

On one side of the diaphragm (the "pitot" side) you have both static and dynamic pressure being applied to it. On the "static" side of the diaphragm you have static pressure only being applied. Since "static" pressure of the air has been applied to both sides of the diaphragm, they "cancel each other out", and the diaphragm responds to the dynamic pressure only.

Airspeed indicators are extremely delicate and sensitive instruments, and therefore you must never blow into them or up their tubes for any reason. If it should ever become necessary to clear a tube of water or dust or check for any obstruction, then disconnect the tube from the instrument first!

INDICATED AIRSPEED AND TRUE AIRSPEED. [PSN, PAGE 38]

True airspeed increases with altitude as against indicated airspeed. At any altitude indicated airspeeds remain the same as far as stall speeds are concerned, but you should be aware of increased true airspeeds at high altitudes from the point of view of inertia loadings etc.

B. GLIDER CONSTRUCTION.**WING LOADINGS AND WING STRUCTURES.**

Loadings (forces) on wings are of three main types– [page 40 PSN]

- (a) Bending loads (up and down loads)
- (b) Torsional loads (Twisting loads)
- (c) "Drag" loads (forward and back loads)

Bending loads (up and down loads) [PSN, page 40]

A simple bending load on a beam (as in diagram _ seesaw, plank etc) results in three different types of forces _ **tension**, **compression**, and **sheer** forces. The same is true of a wing.

Bending loads are of course the main loads on a wing; sheer loads are secondary, but nevertheless important at certain parts of the wing, e.g. root fittings and anchor points.

Spars take most of the **bending** and **shear** loads on a wing.

Refer to page 41, PSN for an illustration of typical spar construction. A wooden or metal spar might have two large sections, one running along the top, and one along the bottom of the spar. These stronger, heavier sections are called the **booms** of the spar.

The parts connecting the two booms are called **webs**, and it is the **webs** that are designed to take the **sheer** loads along the wing.

Under normal flight conditions, the top boom, or top surface of the wing is under **compression** loading, and the bottom boom is under **tension** loading.

Most materials have a greater tolerance to tension loading than to compression loadings, that is they will fail (buckle) under smaller compression loadings than tension loadings.

In a modern GRP ("fibreglass") or carbon fibre glider, the wing spars are often constructed of solid beams of glass or carbon fibre laminate.

Near the wing-tips, bending loads are smaller, so the spar size and depth can also be smaller. A spar will typically taper towards the wing-tip. This saves both on weight and the cost of materials.

Under normal flight conditions the main bending loads (caused by lift) are concentrated along the wing at about **one third** of the way back along the chord line from the leading edge. The wing is naturally made strongest at this point, and this of course is where you find the spar.

However, at higher speeds, the centre of pressure acts further back along the chord, causing both new bending and **twisting** loads on the wing. The twisting loads in particular must be resisted by the structure of the wing or failure could occur.

Torsional loads (Twisting loads) and "Drag" loads (forward and back loads)

Both of these types of load are resisted by **torsion boxes**, which form part of the wing section. The "boxes" may consist of a "D" box construction on the leading edge of the wing in older types of glider (particularly wooden wings, such as K8, K13 etc.). Sometimes the whole wing skin forms this "box" type section, and in other designs there may be two "D" boxes, one running along the wing in front of the spar, and another behind. [pages 40 & 41, PSN]

The "torsion box" structure formed either by the skin or by special wing sections is vital to the structure of the wing. Damage to the box structure, whether internally or on the surface is very serious, and no glider should be flown until any such damage is properly repaired. Such damage can be caused by careless ground handling, or bad trailering, or sloppy rigging or de-rigging of gliders.

Some torsion loads on the wing are also carried by the wing-root fittings, and sometimes also by a secondary spar. Damage to any of these items is also very serious, and could result in wing failure or further damage due to excessive loads torsional loads.

Damage to spars, wing-roots, leading edges etc. can occur through ground loops, heavy landings, or when any undue drag loads are applied to wing-root fittings.

Severe turbulence or a heavy landing may cause damage around airbrake boxes and at the corner of aileron "cut-outs". There are often concentrated Torsional loads in these areas due to the abrupt changes in wing stiffness at these points.

Wing tip damage.

Although not so important structurally as other damage, wing tip damage should be repaired as soon as possible to prevent dampness penetrating inside the wing.

Trailing edge damage.

Although not itself of major structural importance, damage to a trailing edge might be indicative of further hidden damage, such as to ribs, or secondary spars, skin etc. Of course if the wing has trailing edge "D"-box type construction, then any trailing edge damage that interferes with the integrity of the Torsional rigidity of the wing is indeed most serious.

If there is any doubt about any damage you discover, do not fly the aircraft, but note it in the DI book, and report the damage to a qualified engineer ASAP.

Rigging pins and wing-root fittings.

Root end spar fittings and main rigging pins take very large loads indeed. Wing-root fittings should always be examined carefully after a heavy landing or excessive flight loads. Any sign of movement or damage to these fittings should be thoroughly investigated.

FUSELAGE STRUCTURES.

These are of three main types:

1. Truss or open frame – (K13, K8, Motorfaulke)
2. Skin & longerons – (K6, Blanik)
3. Monocoque type.

In this third (monocoque) type of construction, longerons are dispensed with, and the skin itself is made heavy enough to take all of the loads on the fuselage. This is a convenient method in glass fibre construction. The skin may be either consist entirely of layers of fibreglass cloth, or of a "core" of balsa or foam material (perhaps of "honeycomb" type) "sandwiched" between inner and outer layers of glass cloth. The inner and outer layers of glass provide the necessary strength and protection, and the "core" material provides the shape. Materials that are reasonably rigid but light are used for this purpose.

FUSELAGE LOADS.

The largest loads (forces) on a fuselage are bending loads, such as may be experienced in high-"g" manoeuvres, e.g. a high speed pull-up from a dive. [page 43 PSN].

This diagram, as well as showing the considerable bending loads present in such a manoeuvre, also shows **inertia loadings** acting downwards on both ends of the fuselage.

[EXPLAIN INERTIA LOADS]

CHECKS FOR DAMAGE AFTER ANY UNUSUAL STRESSES ON A GLIDER.

After a **heavy landing**, check–

- (i) Around the landing gear.
- (ii) Around the wheel box.
- (iii) Under the pilot's seat.
- (iv) Around the tail-wheel or tail-skid area, including the structures immediately above it. Any damage towards the rear of the fuselage can be most serious because of the high loads that this area can be subjected to in flight.
- (v) The fuselage, particularly around the points of impact.
- (vi) The wing-root fittings.

After a **ground loop**, check–

- (i) The fuselage, particularly towards the rear. The whole of the fuselage skin should be carefully examined for any "rippling" or "crazing" or cracking of the gelcote (on GRP gliders). Any sign of "crazing" or cracking of the gelcote (on GRP gliders) is almost certainly an indication of damage, and should be checked out by an engineer. Particular attention should be paid to any points of impact in cases of **side-loads**.
- (ii) The tail-fin and stabiliser assembly. Any heavy sideways loads on the fin and tailplane assembly can cause high Torsional loads, particularly in the case of "T-tail" types. These may occur during a ground loop by a tail end striking an obstruction such as a clump of earth or a rut in the ground whilst moving sideways.
- (vi) The wing-root fittings.

After any **unusual flight loads**, check any obvious points of stress, such as wings, wing-root fittings, fuselage, tail-fin and tailplane assembly etc.

WING ATTACHMENT PINS.

Wing attachment pins are always under **sheer** forces. [page 44 PSN].

RIGGING AND DE-RIGGING.

A few points to bear in mind–

- (i) **Always remove the tail first**, and fit it last when de-rigging and rigging.
- (ii) **Control connections.** After connecting up control connections, check the control movement from both ends as well as the connection itself. If the control connection cannot easily be seen or checked, try to separate the two fittings, and then re-check by having someone hold the cockpit control while you check the actual control surface for any play in the system. All control

connections should be checked in this way anyway for correct movement and any excessive play. Check the airbrakes for correct movement in a similar way, and in particular check for correct movement and locking in the closed position.

C. GLIDER LIMITATIONS.

[See PSN, pages 46-50 for an in-depth explanation of different types of glider loadings, maneuvering and gust envelopes etc.]

You should read through those pages for your own purposes. The following is a summary of the essential points needed for the exam. A glider can be kept within its designed operating limitations by observing the following rules–

WEIGHT LIMITATIONS.

These consist of such things as minimum and maximum cockpit loadings, maximum water ballast weights, "maximum all-up weights", etc.

The structural integrity of the wings, wing-root fittings, undercarriage, and the stall and spin recovery characteristics of the glider are all affected to some extent by weight loadings and distribution.

CENTRE OF GRAVITY LIMITATIONS.

- (i) Too far forward _

Leads to excessive tail loads and trim drag.

- (ii) Too far aft _

Leads to instability pitch-wise, and bad stall and spin recovery characteristics.

SPEED LIMITATIONS.

V_{ne}

Exceeding V_{NE} could lead to **flutter** and structural failures.

Maximum Rough Air Speed.

This speed is usually indicated on the ASI by the beginning of the yellow range. This limitation is designed to keep loadings imposed in turbulence or gusty conditions within design limits.

Maximum maneuvering speed.

This is a speed below which a full-scale sudden deflection of a control surface will do no harm. (For example, the wing will stall before any overloading occurs.)

However, above this speed, a rapid or excessive control movement can cause damage! For instance, at V_d (maximum designed dive speed), the glider might only be stressed for a **one third** deflection of the controls!

Other Miscellaneous Speed Limits.

Maximum aerotow speeds, maximum winch speeds, Maximum flaps extended speeds etc must also be observed **at all times**.

[An asymmetric flap failure at speed could be very embarrassing!]

MANOEUVERING LIMITATIONS.**Excessive aileron Deflection at high speeds.**

Excessive aileron deflection at high speeds can accentuate the twisting effect of the down-going aileron because of the already aft centre of pressure. In extreme cases this could lead to structural damage and/or failure.

Excessive elevator deflection at high speeds.

Excessive elevator deflection at high speeds can give rise to "g" forces outside of the maneuvering envelope.

The rule regarding **any** control movement at high speed is to use smooth control movements, making them as slight and as gentle as possible.

Always treat the glider with respect and it will not let you down.

OTHER MISCELLANEOUS LIMITATIONS.

Other limitations and specifications for such things as tow ropes, tow hooks, winch weak-links etc are mentioned on page 49 of the PSN, and you can read about those for yourselves. They are not dealt with in the exam.

[PART III ENDS HERE]

PART IV – METEOROLOGY

DEFINITION.

The study of motions and phenomena in the atmosphere. We as glider pilots are only concerned with the lower levels of the earth's atmosphere, known as the **troposphere**. The **troposphere** extends from ground level up to about 35,000 feet (10,500 metres). Almost all weather phenomena, such as clouds, convection etc occurs in this part of the earth's atmosphere.

COMPOSITION OF THE ATMOSPHERE.

The air we breathe is a mixture of gasses. Gas Composition by Volume is approximately–

- Nitrogen 78%
- Oxygen 21%
- Others (CO₂, Argon, other gases, and a **variable amount of water vapour** 1%

AIR PRESSURE.

Air, as a mixture of gases, has **weight**, and therefore has **density**. Air is compressible, and therefore has a greater density in its lower layers due to the weight of the upper layers bearing down on them. It may help to think of the air as a large haystack. The higher we go in the atmosphere, the less air there is above us, and the **pressure** will therefore be less.

The **millibar** (mb) is the basic measure of atmospheric pressure normally used in aviation meteorology. It is equivalent to the **hectapascal**.

In New Zealand the average sea-level pressure is a little over 1010 mbs.

The decrease of pressure with height is about **1 mb** for every **30 feet** of ascent.

Air pressure may sometimes be measured in other units, such as lbs./sq. in., or in inches of mercury etc.

Air pressure at any given place may change frequently from day to day, and often may change from hour to hour.

Pressure distributions and air temperatures play a vital part in determining wind and weather conditions.

ISOBARS.

An **isobar** is a line drawn on a chart or map connecting places with the same sea-level barometric pressure.

[PSN, page 63].

Diagrams 4 and 5 on page 63 clearly show the **isobars** associated with the particular weather systems depicted there.

PRESSURE GRADIENT.

The **pressure gradient**, or **rate at which the atmospheric pressure changes with distance**, is said to be "weak" when the spacing between the isobars is wide, and "strong" when the isobars are closer together.

[SEE DIAGRAM 2, page 61 PSN FOR AN EXPLANATION OF PRESSURE GRADIENT].

The **strength** of any **wind** will tend to be influenced primarily by the pressure gradient _ i.e. a strong pressure gradient will generally mean stronger winds, and vice versa.

WIND DIRECTION.

(i) "Geostrophic" wind.

Generally, the wind blows in a direction **parallel to the isobars!**

[DIAGRAM 2, page 61 PSN].

This effect is due to a combination of three different types of forces—

- (a) Pressure gradient
- (b) Geostrophic forces (due to the earth's rotation)
- (c) Cyclostrophic force (centrifugal force).

(ii) Wind direction around "high" and "low" pressure areas.

[DIAGRAM 2, page 61 PSN].

OTHER CHARACTERISTICS OF "HIGH" AND "LOW" PRESSURE AREAS.

A **low** pressure area is a region of **rising** air currents, with much precipitation and cloud due to **adiabatic cooling** of the air. A **high** pressure area is an area of **sinking** air. The air subsides at about 300 feet per day, and this air is **heated adiabatically**.

The longer the "high" lasts, the warmer the weather is likely to become. (Hot, sticky summer days). An **inversion** may often develop at an altitude of several thousand feet, and in winter, sometimes an 8/8 deck of stratocumulus clouds may form. This layer of cloud is aptly called "anti-cyclonic gloom" by meteorologists (and by glider pilots!). Such inversions and/or cloud cover can sometimes last for several days.

"Highs" or anticyclones are therefore not often the best conditions for gliding, because of –

- (i) "Sinking" or subsiding air (leading to stable conditions),
- (ii) Inversions (stable air),
- (iii) "Anticyclonic gloom" (inhibiting thermal development.

LAPSE RATE.

The **lapse rate** is the name given to the **rate** of change of temperature with height. Air will normally be **cooler** with **height**.

The normal lapse rate for **dry** air (DALR) is **3°C per 1000 feet**.

For **saturated** air it is **1.5°C per 1000 feet**.

The standard average lapse rate is about 2°C per 1000 feet.

[DIAGRAM Nos. 17, 20, 23, on page 69, 70, AND 71, PSN for further explanations of lapse rates].

Lapse rates are the main factors determining the vertical stability of the atmosphere, and hence the probability of convection and thermal formation.

INTERNATIONAL STANDARD ATMOSPHERE (ISA).

ISA is a hypothetical international standard atmosphere used for the calibration of instruments and for the control of air traffic at high altitudes (flight levels etc.). The **ISA** assumes a sea level pressure of 1013.2 mb at a temperature of 15°C and a lapse rate of about 2°C (in fact 1.98° C) per 1000 feet. This lapse rate is assumed to continue to about 36000 feet, above which it is assumed to remain constant at -56 °C.

ALTIMETERS.

A discussion of air pressure leads us to a discussion about how altimeters work.

An altimeter is really a form of barometer which works the same as an aneroid barometer on the principle of an aneroid capsule. The term "aneroid" is used to describe an instrument that measures air pressure by its action on an evacuated or partly evacuated capsule rather than by the height of a fluid column. An altimeter, however, is much more sensitive than a barometer such as would hang in one's hallway. Modern altimeters will indicate heights to within 10 feet or so.

[REFER DIAGRAM 21, page 71, PSN FOR A BASIC EXPLANATION OF AN ALTIMETER.].

A pressure sub-scale in millibars is fitted to the altimeter to enable the altimeter readings to be adjusted for changes in atmospheric pressure which changes from time to time. When the sub-scale is adjusted to read the sea level pressure at the time, then the height scale will show the height of the altimeter above sea level. If the height scale is adjusted to read zero the reading on the sub-scale will show the pressure at the height of the instrument.

Modern altimeters are calibrated in terms of the ISA (see previous section).

PRESSURE CHANGES ON LONG FLIGHTS.

You should be aware that on a long cross-country flight (or even a long local flight), pressure changes in the atmosphere over time can affect your altimeter reading.

If you are flying from a higher pressure area into a low pressure area, your altimeter will read high. It will tell you that you are **higher** than you are.

The converse also holds true.

A good rule of thumb to remind you of the likely corrections to be made is—

HIGH	➔	LOW	➔	HIGH
LOW	➔	HIGH	➔	LOW

As a guide to possible pressure changes, if you generally have your back to the wind during the course of the flight, the higher pressure area will be on your left, and the lower on your right.

EXERCISE: If on a long cross-country flight you experience drift to port, will your altimeter read high?, low?, or the same? at the end of your journey?

[PSN, page 69, DIAGRAMS 15 AND 16.]

ADIABATIC COOLING AND HEATING.

The term “adiabatic” is used to describe the cooling or heating of air which is due to a change in its “**pressure**” only. That is it is **not** due to an exchange of heat with its surroundings. These pressure changes are usually brought about because the air is **ascending** or **descending**.

A parcel of air **ascending** or **descending** in the atmosphere will cool down or heat up.

LATENT HEAT.

If large quantities of water vapour are present in the air then latent heat will either **released** from the air mass or **absorbed** by it whenever **condensation** or **evaporation** takes place. This heat exchange has a different cause to the **adiabatic** cooling or heating mentioned above. Thus, when invisible moisture vapour in the air condenses to visible droplets (i.e. a cloud forms), **latent heat of condensation** is given off into the surrounding air, and can further boost the vertical action of a cloud in unstable conditions.

Largely because of these heat exchanges, when **moist** or **saturated** air rises or falls, its adiabatic lapse rate is **less** than that of dry air.

This situation is good from a glider pilot's point of view because it means that **moist air** will **cool slower** as it rises than will dry air, and therefore it will rise higher than any surrounding dry air before it reaches surrounding air of the same temperature. It will be more **unstable** or **buoyant** than dryer air.

SATURATION.

The amount of water vapour that a body of air can hold at a given temperature and pressure is limited. As the temperature of the air falls, its capacity to hold water vapour also falls, until the point is reached where the air simply cannot hold more. This temperature point is called the **dew point** of the air. Further cooling of the air beyond this point results in some of the water vapour condensing in the form of water droplets. Cloud or fog is then formed. Ice crystals may be formed at temperatures of minus 40° C.

CONVECTION.

The surface of the Earth is heated by solar radiation (called **insolation**). The air itself receives little direct heat energy from the sun. The surface of the Earth absorbs this heat energy and re-radiates it to heat air in contact with it. Heated air will form in uneven "pockets". When sufficiently buoyant view to expansion, i.e. less dense than the surrounding air, these "pockets" of air will rise into the atmosphere in the form of **bubbles**, or sometimes as a **constant steam**. When a rising pocket of air contains sufficient water vapour, cloud will form when the air reaches its **condensation level**. This "level" tends to be the same for all clouds formed by convection in the same area at the same time. We call this level **cloud base**.

[Refer PSN, page 65, diagram 9]

The height of **cloud base** is one of the major limitations on cross-country glider operations when the glider is not permitted to fly in the cloud itself. Obviously, the higher a glider can climb in good thermals, the further and faster it can go on cross-country flights. A low cloud base may mean that cross-country flights are not feasible at all, restricting gliding to local soaring close to the field.

STABILITY AND INSTABILITY.

The ocean of air that extends above us varies greatly in pressure and temperature. The weight of the air above us causes a fairly high pressure and temperature to exist at sea level. Let us select a cubic foot of air at sea level and gradually lift it to higher and higher altitudes without restraining its size or shape. As we move our block of air higher in the atmosphere we find there is less air above it, and thus the pressure is lower. The lower pressure permits our block of air to expand. As it expands in volume, it also cools. If the pressure and temperature at the surface of the earth were the same everywhere, then all units of air would behave exactly the same as our sample block of air and the temperature and pressure of the atmosphere would be uniform. This idealized state of the atmosphere is stable. If we released our block of air at any altitude, it would stay at that altitude since the temperatures and pressures are the same for all the rest of the air at that altitude. The rate of change of temperature with altitude for this idealized state is called the Adiabatic Lapse Rate, and is a very useful reference for glider pilots.

Our atmosphere is far from the idealized structure just described. Storms and winds cause warm and cold air masses to move around and interact in various ways, resulting in temperatures over a particular location that are significantly different from the Adiabatic Lapse Rate. If, when we lift our block of atmosphere to a higher altitude, we find that the temperature of our little block is warmer than the surrounding air, then the block will continue to rise seeking an altitude where the temperature is the same. This condition is indicated by measured air temperatures at higher altitudes that are LOWER than the Adiabatic Lapse Rate, and the air mass is considered to be “**unstable**”. [Note temperatures LOWER than the Adiabatic Lapse Rate = a HIGHER than standard lapse rate.] In this atmosphere a bubble of warm air will rise higher than otherwise, causing the instability. If, on the other hand, the temperature of our block of air is cooler than the surrounding air, it will sink back to a lower altitude seeking air at the same temperature. This is indicated by measured temperatures at higher altitudes that are HIGHER than the Adiabatic Lapse Rate [a LOWER than standard lapse rate] and the air mass is considered “**stable**”.

Clearly therefore the best conditions for thermal soaring are when the atmosphere is "unstable" and bubbles of warm air (hopefully containing gliders) will rise as high as possible. The other key aspect of thermal soaring is the requirement for the sun to warm the earth's surface to temperatures well above that of the air near the surface.

We call an atmosphere with buoyancy and vertical development an **unstable atmosphere**. The atmosphere will be **stable** if the general temperature lapse rate in the surrounding air is **small**, and, therefore, a warmed parcel of air may only rise a short distance (if at all) before it encounters air of the same temperature. When a parcel of air reaches the density of the surrounding air it will stop rising. **The density is the important thing**. Remember that, for a given pressure, warm air is less dense than cold air, and when it encounters an environment at the same density it will cease to rise in that environment.

Stable air is not conducive to thermal development, but is conducive to the production of lee waves (standing waves) behind a ridge or mountain range if other suitable conditions exist.

[PSN, page 71, diagram 23 for an explanation of stability and instability]

OVER-DEVELOPMENT (EXTENSIVE CLOUD COVER).

[Discuss the cause of over-development and its effect of on thermal development.]

INVERSIONS.

Ordinarily, air temperature **decreases** with altitude. However, under some atmospheric conditions, the temperature may stay the same, or may actually **increase with** height. Where the temperature **increases** with height we have an **inversion**.

An **inversion** produces very stable effects, acting as a “lid”, as it were, on any vertical development. Even buoyant air may become “trapped” under the **inversion layer**.

An **inversion** layer may be marked by smoke, haze, fog, or stratus cloud. An **inversion** will limit thermal development, and may quash it altogether, producing smooth stable air.

Inversions may be prevalent in anticyclonic conditions.

[PSN pages 70, 71, diagrams 20 and 23 for explanation of effect of **inversions** on convection.]

Sometimes thermals can develop quite happily underneath an inversion layer, and may even produce small “fair-weather” cumulus clouds underneath the layer. These may be fairly shallow in height, but still “soarable”. Occasionally, really strong thermals may “punch through” the inversion layer in parts.

Several likely causes of inversions are—

- (i) Warm, moist air coming in over a cold sea or land mass.
- (ii) Warm upper air moving in over cold lower air, as with the approach of a warm front.
- (iii) Anticyclonic conditions—

In a high pressure area, with light winds, the whole air mass may be descending, acting as a “lid” on thermal development. Sometimes in such conditions a thin deck of stratus or strato-cumulus clouds will form. Air descending near the cloud layer will not only be heated adiabatically, but also by the heat produced by the latent heat of condensation from the cloud.

- (iv) In industrial areas, the continued presence of an inversion can result in a smoky, gloomy pall, consisting of warm stable air mixed with smog or fog.

FOG.

Fog is really only condensed water vapour (cloud) which has formed at or near ground level. Fog is usually classified according to its two main methods of formation–

- (i) Radiation fog,
or
(ii) Advection fog.

- (i) **Radiation fog** occurs on clear, cold, still nights, when moist air stagnates over the ground, and is cooled by contact with the ground. The ground loses its heat rapidly by night, and the air in contact with the ground is cooled below its **dew point**, forming fog.

Radiation fog is typically a feature of anticyclonic conditions, especially in **winter**, forming mostly over flat ground and in sheltered valleys.

- (ii) **Advection fog** is formed when warm moist air moves over a colder surface, e.g. over a cold portion of the sea. This is one of the most common types of advection fog, and occurs most often in **spring** and **early summer**.

Fog of either type is normally dispersed during the succeeding day, but, if not dispersed completely, may rise to a few hundred feet and create a local inversion. It may mix with industrial smoke to form smog, which may last for several days.

“WIND-SHADOW” THERMALS.

[PSN, page 71, diagram 22.]

Where the terrain is hilly, warm air may often lie undisturbed for a time in the lee of a hill, or in a small valley, until it becomes buoyant, and develops into a thermal. Such areas can become good thermal sources, particularly where they are well warmed by the sun. They are in the “shadow” of the wind, but generally not the sun. Hence their name, “wind-shadow” thermals. Sometimes such areas may be the **only** source of workable thermals in windy conditions.

CLOUD COVER.

Cloud cover in aviation meteorology is defined in terms of **OCTAS** (eighths).

For example, **total cloud cover** is referred to as “8/8”, or “**eight octas**”;

50% cover as “4/8” or “four octas”; and 25% cover as “2/8” or “two octas”.

CLOUD TYPES. [PSN, PAGE 54]

(i) High level cloud. (bases from 20000 feet, tops to 40000 feet)

- (a) cirrus (“tendrils”) **C_i**
- (b) cirrostratus **C_s** (“stratus” = “layer”)
- (c) cirrocumulus **C_c** (“cumulus” = “heaped”)
- (d) alto cumulus lenticularis (lenticulars)

(ii) Medium level cloud (bases from 7000 feet, tops to 20000 feet)

- (a) Alto cumulus **A_c**
- (b) Altostratus **A_s**
- (c) alto cumulus lenticularis (lenticulars)

(iii) Low level cloud (ground level to 7000 feet)

- (a) cumulus **C_u**
- (b) towering cu **C_u**
- (c) cumulo-nimbus **C_b**
- (d) Stratus **S_t**
- (e) Strato-cumulus **S_c**
- (f) Fog.

NB – Towering cumulus (TC_u) can range from 1000 feet at the base to 10000 at the tops, and C_bs from 500 feet to 20-40000 feet, so there can often be some overlap in the above levels.

[PSN, page 54 for a list of the various cloud types.]

[PASS CLOUD CHARTS AROUND]

It can be seen that cumulo-nimbus clouds can be formed by the strongest vertical development of all the cloud types (500-40000 feet).

It is C_bs that produce thunderstorms, and are to be avoided by glider pilots at all costs. This is because they may contain all or any of the following–

- (i) Severe turbulence

- (ii) Severe wind shear (both vertical and horizontal)
- (iii) Lightning
- (iv) Hailstones
- (v) Ice
- (vi) Rain

The area surrounding a large C_b may for some considerable distance be one of severe downdrafts and be useless for soaring. Closer in there could be rain, hail, lightning, turbulence etc, so avoid them at all costs.

OROGRAPHIC CLOUD.

Orographic cloud is formed by air rising over hills or mountains. Cloud is formed by air flowing up the slopes, cooling and condensing as it rises. The cloud is called **orographic cloud**, and any resultant rainfall is called **orographic rain**.

[PSN, page 57, and diagram 27 on page 74]

CLOUDS ASSOCIATED WITH STANDING WAVES.

“Standing” (or “lee waves”) can produce a number of cloud types associated with the wave systems. [PSN, pages 74, 75, diagrams 27 and 28]

The main types are–

- (i) Lenticular clouds

These are lens-shaped clouds, often elongated or cigar-shaped. They usually have smooth, well-defined shapes. Often they can “stack up” on top of one another like a pile of plates.

These clouds stand relatively still in the sky, despite the strong winds at their altitude. The upwind edge is continually forming with “lift”, and the downwind edge dissolving with “sink”. The airflow into and above the cloud is smooth, but very rough air may be encountered underneath the cloud. [See diagram 27, page 74.]

- (ii) Cap cloud.

The orographic cloud which sometimes “caps” a range of hills or hill during lee wave formation.

- (iii) Roll cloud (rotor cloud).

A turbulent, stationary cloud which sometimes forms underneath a lee wave, rotating like a roller over which the wave rides. From a distance it may look innocuous enough, but from close up it is violently active, and has a ragged appearance. The top surface of the roll cloud is moving over itself with the wind, and then tucking underneath so that the wind under the roll cloud may be the exact reverse in direction to the general wind. Strong unpredictable

winds can occur right down to ground level in wave conditions, making assessing wind direction for landing in such conditions extremely tricky.

[See the diagram on page 74 for this reverse flow under the roll cloud, which can occur down to ground level! The winds can be extremely turbulent and gusty, as well as being unpredictable in strength and direction.]

HAZARDS OF WAVE FLYING.

- (a) “Gaps” in the clouds, such as the **föhn** gap may close up suddenly, and the glider could find itself suddenly in cloud in strong wind conditions.
- (b) The “phase” of the wave may shift suddenly, along with the associated cloud patterns. This shift may be either **upwind** or **downwind**.
- (c) Misjudgment of wind strength allowing the glider to drift downwind out of the lift area or into cloud.
- (d) Severe turbulence and downdrafts in the air.
- (e) Rotor flow (turbulence, unpredictable gusty winds, particularly on landing near or underneath the rotor system.)

CONDITIONS NECESSARY FOR THE FORMATION OF LEE WAVES.

- (i) **A range of hills** (or a reasonably large hill or mountain.)
- (ii) A wind blowing **within about 30° of either side of the perpendicular** to the range of hills.
- (iii) **Wind of sufficient strength** (about 20 kts or more at ridge height), preferably increasing in strength with height.

[NB – the wind strength **on the ground** need not be very great, e.g. at Matamata good, well-defined wave systems can develop when the wind on the ground may be only a gentle 5-10 kts.]

- (iv) Some **stability** in the air, as convection can disrupt wave patterns, or prevent them forming at all. A stable layer in the mid troposphere sandwiched between layers of less stable air above and below is ideal.

If all of these conditions are met, lee waves may occur almost anywhere in New Zealand. Some areas are of course better than others, e.g. the Southern Alps, Kaiamai Ranges, Ruahine Ranges.

The formation of lee waves is also often helped by a **katabatic** wind (cooling air flowing down the lee of the slope). This is why waves often set in rather suddenly in late afternoon or evening as the katabatic wind becomes established.

[PSN, pages 56, 64, diagram 8.]

FÖHN WIND.

A **föhn wind** is a warm dry wind flowing from mountain ranges, having crossed them from the other side and lost its moisture on that side due to condensation and precipitation. The wind gains heat from the **latent heat of condensation** and emerges onto the lee side of the ranges as a warm or hot dry wind (e.g. the Nor'wester across the Canterbury plains).

[PSN, page 74, diagram 27 for an explanation.]

NB – A **föhn wind** may be present without the formation of standing waves!

RIDGE FLYING.

Points of airmanship to note (apart from the “give-way” rules on ridges) are–

- (i) Finding the best area of lift. [PSN, page 68, diagram 14.]
- (ii) Curl-over – in the lee of the ridge.
- (iii) “Bolster eddies”.

Beware of going back too far behind a ridge because of–

- (a) The “curl-over” effect (downdrafts, turbulence etc) and,
- (b) The wind strength.

If you must go behind a ridge in windy conditions, e.g. to get into a wave system, then make sure you go behind with **plenty** of height in reserve to cope with any downdrafts or turbulence which will almost certainly be present.

[PSN, page 68, diagram 14.]

FRONTAL SYSTEMS.

The area where two differing air masses come together is called a **frontal zone**. It is the demarcation area, or zone, which is often not sharply defined, but will represent a gradual change in weather conditions as one air mass replaces or overtakes the other.

When a front moves so that cold air displaces warm air at the ground, it is termed a **cold front**, and the reverse is termed a **warm front**.

A coalescence or joining of **two different frontal systems** is called an **occlusion**.

[Fronts and frontal symbols are depicted in very basic form on PSN, page 62, diagram 3. See also pages 63 and 66.]

COLD FRONTS.

Cold fronts can vary greatly in structure and form. They are often associated with **depressions** or “**lows**”, and their distance from the centre of the depression and the intensity of the depression can affect the form of the cold front.

[The basic “text-book” form, however, is shown in diagram 11 (left-hand half), on page 66 (PSN)].

The diagram shows a cross-section of the front, which is moving from left to right.

The essential features of a cold front are–

- (i) Cold air approaching and acting as a “wedge”, displacing warmer air upwards before the frontal slope, resulting in **cooler temperatures**.
- (ii) The rising warm air often forms **C_{bs}** or **TC_{us}**. Heavy rain and possible thunderstorms may be present for a time.
- (iii) **Line squalls** may be present. These are abrupt wind shifts of strong gusty winds, which are often accompanied by heavy rain. They occur just before and during the passage of a cold front and its associated cloud development. They are more common in winter, and this is why there is a mad rush to close canopy windows and picket down gliders securely when you see frontal clouds approaching.
- (iv) A cold front is usually a lot shallower than a warm front, and therefore passes relatively quickly (usually within a few hours).
- (v) The air behind the front will usually clear rapidly. Some cumulus clouds or TC_{us} may develop, and some showers are likely following the passage of the front, until it clears completely.
- (vi) A cold front is often followed by excellent soaring conditions within a matter of hours (or the next day). **This is because of the clear, unstable, moist air which is particularly amenable to thermal development.**

WARM FRONTS.

The essential features of a warm front are–

- (i) An extensive area of cloud cover, usually beginning with high cirrus cloud, forming anything up to 500 miles ahead of the front. This is gradually followed by thickening C_s, A_s, S_c, and N_s cloud, with extended periods of rain or drizzle.
- (ii) Because the warm front is much deeper in cross-section than a cold front, its passage takes longer.

- (iii) Stratus and strato-cumulus may develop in the warm, moist air following the passage of the front.
- (iv) Gliding conditions throughout the whole passage of the front, and for some time after will usually be poor due to extensive cloud cover, rain, drizzle, and poor visibility.

CHANGE IN WIND DIRECTION FOLLOWING PASSAGE OF FRONTS.

Generally, the wind direction will “**back**” considerably with the passage of **any** front.

[PSN, pages 62, 63, diagrams 3 and 4, for good depiction of this phenomena.]

LOCAL WEATHER SYSTEMS AND EFFECTS.

Sea breezes and sea breeze fronts.

During the day, land areas near the coast are heated by the sun. Warm air rises over this land area, and is replaced by cooler air over the nearby sea, or a lake. Hence the term “sea breeze”. At night, the process is often reversed, creating a “land breeze” out to sea.

Although sea breezes do not usually penetrate beyond the ranges nearest to the coast, there are places where gaps permit them to reach far inland.

Where a sea breeze encounters resistance from other wind systems, a **convergence zone** may form. Such an area is sometimes called a **convergence front**. It acts like a tiny cold front, creating vertical movement of the air upwards. Such “fronts” (called “sea breeze fronts”) are often marked by cumulus clouds and provide a good stationary “street” of soarable lift along the line of the convergence.

[PSN, page 64, diagram 7.]

NB– This diagram, however, does not properly depict the true reasons for the development of a sea breeze front or convergence line.

Anabatic and katabatic winds.

An **anabatic wind** is an **upward-flowing** wind, and a **katabatic wind** is a **down-flowing** wind.

Anabatic winds are caused by daytime sunshine heating. When the ground warms, the air close to a hill heats quicker than that over adjacent lowlands, causing it to rise in a weak and shallow flow up the slope.

A **katabatic** wind is exactly the reverse. It is a downward flow of cooler air.

[PSN, page 64, diagram 8.]

Wind gradient or wind shear.

We have already earlier briefly discussed wind gradient under “airmanship considerations”. The effect of a wind gradient is depicted rather well in the diagram on page 72 [diagram 24]. Basically the problem is that a glider on a steady approach path flying into a wind that is decreasing as it gets nearer the ground will suffer an increasing loss of airspeed, and may even stall if corrective action is not taken early.

The loss of airspeed also means loss of lift, and the glide-path will also suffer appreciably if corrective action is not immediately taken.

One of the reasons why we always fly at a safe speed near the ground is to allow for the effects of wind gradient.

Corrective action **must** be taken immediately the first indications of wind gradient effect are noticed.

[WHAT WILL YOU NOTICE?]

A sudden fall off in airspeed or sudden deterioration of the glide-path.

Strong or gusty winds may also cause penetration problems, and this must be allowed for in your approach speed.

[WHEN MIGHT YOU EXPECT TO ENCOUNTER WIND GRADIENTS?]

Effect of strong winds on thermals.

Appreciable winds will blow the thermal into a sloping path downwind as it rises. The angle of the slope depends on the wind speed.

e.g. a 5 knot thermal in a 20 kt wind will only rise at a slope of 1:4, but a 10 kt thermal in a 10 kt wind will in theory rise at 45° etc.

Therefore, in any appreciable wind, look for your thermal on a sloping line upwind from the cloud that it appears to be producing.

PART V – HUMAN FACTORS IN GLIDING¹

DEFINITION OF “HUMAN FACTORS” IN THE AVIATION CONTEXT.

“Human Factors” is a general term which broadly encompasses the study of human performance and limitations pertaining to the piloting of aircraft, both in the air and on the ground. The term “Human Factors” came into being relatively recently as a result of the increasing importance of a pilot or human component as a cause of aviation accidents, including gliding accidents worldwide. However, its scope now goes beyond accident investigation to embrace all of the medical, psychological and ergonomic/engineering aspects of human beings in the aviation environment.

Because human factors continue to play a large part in aviation accidents, they will continue to be of interest and concern to all aviators. Recent studies show that more than 75% of all accidents have significant “human” causal factors.

[HANDOUT APPENDIX VI – PROPORTION OF ACCIDENTS DUE TO HF]

An understanding of our limitations as human beings in the aviation environment is just as important as an understanding of aircraft limitations in making our sport as safe as we can. We will not eradicate human error, but we can and should work towards managing it and reducing its negative consequences.

A broad knowledge of factors affecting human performance and limitations in the aviation environment is now required of all qualified glider pilots by law in New Zealand.

HUMANS AND THE “NORMAL” AND “AVIATION” ENVIRONMENTS.

Human beings are well adapted to living on the earth’s surface at moderate temperatures, breathing a sea-level atmosphere, in conditions of good visual orientation references, and generally moving about at slow speeds under a gravitational forces of 1“g”. Disturb any of those conditions and the human being is placed in an environment that is as unnatural and potentially hostile as that under water or in outer space. The aviation environment itself can disturb all of these conditions.

Affected to a greater or lesser extent are normal human functions of–

- Vision
- Hearing
- Balance and orientation
- Respiration

1 The notes in this part are comprehensive, but the main points which should be emphasised in a course are in yellow “shaded text” (see “styles”) for convenience.

- **Mental capacity** (judgment and decision-making, affected by stress, fatigue, overload etc)

In addition the pilot and passengers must cope with such special **external environmental factors** as–

- **“G” forces**
- **Pressure changes**
- **Temperature changes**
- **Humidity changes.**

Adverse medical factors may also come into play, such as–

- **Influence of drink or drugs**
- **Dehydration**
- **Hypoxia**
- **Disease**
- **Illness**

VISION IN THE AVIATION ENVIRONMENT

Good vision, both inside and outside of the cockpit is obviously essential for safe flight. It is extremely important to us as pilots for the basic function of telling us where we are going, where we have been, and what is sharing our immediate airspace with us. What may not be widely recognised is that vision also plays a major role in the balance and orientation mechanism of the human body, to which we will return shortly. Not only do the eyes provide 80% of the orientation information received by the brain, but the mechanism of vision, including the visual function of the brain requires 30% of our oxygen supply. The visual mechanism is particularly sensitive to hypoxia, and this explains why visual effects are often among the earliest to manifest themselves in this condition.

Limitations of Vision (Factors adversely affecting vision)

We will list these now before discussing some of them in more detail shortly.

Inherent limitations

- The blind spot
- The time lag
- The seeing and focusing mechanism
- Empty visual field blindness
- Visual illusions

Physical impairment

- Muscular fatigue
- Damage – grit cataract
- Congenital or naturally developed conditions such as short or long sightedness, or astigmatism.

Environmental factors

- Hypoxia
- “g forces
- Heat/cold
- Turbulence
- UV or IR Radiation
- Glare
- Luminance, ambient lighting and contrast

Equipment

- Canopy design
- Canopy condition, cleanliness, cracks, scratches, water
- Incorrect sunglasses
- Inappropriate headgear
- O2 masks

The process of “seeing” and “focusing”

The eyes are muscles which, at rest, focus 3 to 4 meters in front of us. For flying we need to be able to focus on distant objects outside of the cockpit (ground features and other aircraft) as well as items inside of the cockpit (instruments and maps). For the pilot the necessary process of effectively “seeing” this wide range of objects at different distances requires muscular effort, special techniques, and a good understanding of how the human vision system works, along with its limitations.

Interestingly, the binocular depth perception attributable to two good eyes only works out to a distance of about 10 meters. Beyond that, pilots are estimating distances by their experience of the comparative sizes, shapes, alignment and perspective of objects they see. However, the eyes can sometimes be fooled in this respect, as we will see when we look at some visual illusions.

The eye can detect light energy of different colours and intensity. Light entering the eye is converted into light energy that the brain can detect by light energy receptors in the retina of the eye.

These receptors are of two types, called **cones and rods**. **Cones are concentrated near the centre of the retina, and detect brighter light energy and sharp, fine detail. The cones also register colour.**

The **rods**, on the other hand, react to much **weaker light energy**, and are **distributed more widely around the retina**. They do not detect as sharp images nor register colours as well as the cones, but **they do detect movement better than cones, especially in the peripheral areas of vision**. This is why, when we detect (or think we detect) some movement “out of the corner of our eye” we instinctively turn our head in that direction to bring the much sharper and fine detailed powers of the cones in the centre of the retina into play.

The blind spot

Most of you will be aware of the existence of an eye’s “blind spot”.

Small nerves behind the retina carry light-generated nerve signals to the brain via the **optic nerve**, an area at the stalk of the eye which they all join up to form. **There are no light receptors (rods or cones) in this area of the retina, so any light energy falling on this area does not reach the visual centre of the brain. This is the eye’s “blind spot”.**

[HANDOUT APPENDIX VII – ANATOMY OF THE EYE]

[HANDOUT APPENDIX VIII – BLIND SPOT DEMONSTRATION NO. 1]

Pilots, or for that matter people generally, are not continually aware of their “blind spot”, as the brain tends to “fill in” what it thinks should be there!

[HANDOUT APPENDIX IX – BLIND SPOT DEMONSTRATION NO. 2]

The “time lag” between “seeing” and “responding”

The time lag in the “seeing” process is particularly important when considering **reaction times**. “Look out” for pilots is **not only a process of looking and “seeing” what may be there, but also a process of recognising, deciding, and responding to what may be there. Just as “seeing” takes a finite time, so does deciding and reacting.**

[HANDOUT APPENDIX X – a typical “time line” of the process]

In ideal conditions anything up to 7.5 seconds may elapse from looking to avoiding. How far do two converging aircraft travel in this time?

At	120 kts closure they travel	1013 - 1520 ft
	150 kts	1267 - 1900 ft
	180 kts	1520 - 2280 ft
	400 kts	3378 - 5066 ft

Scenario – you are in the wave with a 737 or 146 steaming towards you from your wing tip... he has only a very small cross section to detect at nearly a mile... and he may be eating his lunch! How often will you be scanning out at

your wing tip? Sure, the sky is a big place.... but all too often it ends up just a wee bit too small to fit two aeroplanes in!

Scanning

Because of inherent limitations in the seeing and focussing mechanism, seeing something properly presents problems for the pilot, particularly in “lookout”. As we have noted, the best vision during daytime is central vision, using the cones of the central retina. The area of acute vision occurs in a “cone” shape of about 20° angle from the centre of the retina, giving the pilot about 20° arc of accurate vision at any one time. The process of looking, seeing, and recognising does not occur instantaneously, but takes a finite time to happen. In fact, about 1½ seconds under normal conditions! Taking the limited angle of accurate vision available, and the time lag into account, it is clear that to scan the airspace outside of the cockpit effectively a pilot should divide the area to be scanned into 20° sectors, and allow sufficient time in each sector for the “seeing” to fully occur. Because glare, luminance, and contrast factors can delay the “seeing time” even further, allowing 2 seconds per 20° sector is recommended. Hence the development of the “20 Degrees – 2 seconds” rule.

We need to develop a scan that maximises our lookout. The vulnerable areas are ahead of us where we can run into someone and to the side of us from where we may be run into. In aviation the third dimension of above and below and the closure rates possible further increase our visual task.

Obviously we also need to scan back *inside the cockpit* for similar durations (20 Degrees – 2 seconds) to check what is happening there. We need to refocus our eyes; if we have a relatively empty visual field the eyes will focus near their resting distance at about 3 meters in front of us and won’t see objects beyond that. If we have just had them focused on the instruments we should focus our eyes to the distance we want them to scan at by looking at and focusing on a more distant object like a ground feature or cloud, then scan out in our sector.

Empty visual field blindness²

It is important for pilots to be aware that when flying in conditions of low visual stimulus a significant form of “short-sightedness” can occur. Low visual stimulus is where the visual field looks very much the same in all directions, and is relatively unbroken by distinctive or different features. This may occur for example when flying in haze above a solid cloud layer, or over a smooth sea surface. The “short-sightedness” because the eye “rests”, taking up its natural relaxed focal length of about 3 to 4 meters! Under low stimulus conditions the danger is that although the pilot may think he is keeping a good look out, he is in fact focussing just outside of the cockpit!

Empty visual field blindness can be overcome by periodically transferring the gaze to some distant cloud or land feature, thus exercising the focal properties of the eye. Even consciously focussing on the wing tip from time to time may help.

² Also known as “Low visual stimulus shortsightedness” or “Empty field myopia”

The effect of hypoxia on vision.

The brain is very sensitive to oxygen levels, and the visual system is one of the most sensitive parts of the brain. In fact it requires 30% of the body's oxygen requirements! The visual system is therefore extremely susceptible to oxygen deprivation, and will be among the first "systems" of the body to be adversely affected thereby. Visual acuity (sharpness), peripheral vision, colour perception, and visual brightness will all be affected.

The effect of "g" forces on vision.

The application of positive "g" forces will reduce the blood supply to the brain and therefore the oxygen supply to the brain will be diminished. Initially the pilot may notice—

- loss of colour ("grey out")
- loss of peripheral vision (tunnel vision)
- blurring of vision (loss of visual sharpness)
- Total loss of vision ("black out")

N.B.— not the same as unconsciousness, although that may quickly follow if "g" force is maintained!

The effect of fatigue on vision

The muscular side of vision is of course largely automatic, but, like any muscular activity may be affected by fatigue. Focussing and re-focussing of the eye requires a certain amount of energy, and the eyes can be among the first bodily facilities to become tired if the body is tired. We are all familiar with the need to rub, close, or rest the eyes when we are tired. The normal field of vision, visual acuity, and general visual effectiveness all clearly suffer when we are tired.

Canopies and vision.

Do not forget your canopy as a visual aid. It is, because if it was not there you would not see very much because of the airflow in your face. Treat a canopy as you would your favorite pair of expensive sunglasses. A clean canopy is a delight, but a dirty or scratched one is the complete opposite. The canopy should be cleaned well before each flight, inside and out, with a non-abrasive cleaning agent which will not scratch a perspex or glass surface. Any soft clean lint-free rag is a suitable applicator. Wiping should be done vertically rather than horizontally.

Visual illusions

General

The human visual system is not always accurate. It can play very real “tricks” which can fool unwary pilots with disastrous consequences. Because vision is so important to safe flight it is important to understand how visual illusions can occur and anticipate them.

We have already seen the blind spot in action. A pilot in a cockpit with window and door frames needs to be aware not only of the blind spot, but also of the tendency of the eyes to “fill in” gaps in vision without the pilot being aware of what is happening. The eyes could give an illusion of a continuously empty sky, but that door or window frame could hide and approaching aircraft if it is in the pilot’s blind spot. Special scanning techniques are required to overcome this problem.

When the brain receives visual signals from the eyes and its visual centre it tries to “make sense” of what it sees. In order to do this it may fill in gaps or move things around slightly in order to make better sense of the messages it receives. It can bend straight lines, or straighten out curves. It can lengthen or shorten lines. The brain does not always see what is there!

[HANDOUT APPENDICES XI AND XII TO THIS PART].

Height illusions

The human brain is not always good at making visual comparisons, particularly in situations of poor visibility, distracting line features or lack of familiar surrounding objects or features.

For example, when a pilot is familiar with trees of a certain height near his home field, but travels to a different area where the trees look the same shape but are in fact much smaller, the pilot will end up flying much lower if he is judging airfield height by the size of the trees alone! Fatal accidents have been caused by this visual illusion.

Landing area perspectives.

In learning to fly pilots become familiar with the shape and perspective of their home runway, particularly on final approach. They learn how the perspective changes when they are either higher or lower than normal. But this familiar perspective can “trick” the pilot when landing on a different runway.

For example, a pilot used to landing on a relatively short runway may think he is too high when approaching a much longer runway at a correct approach slope. The pilot may take unnecessary corrective action, and end up dangerously low. The exact reverse may be true when flying onto a runway shorter than the pilot is used to.

Runways sloping uphill or downhill can produce similar illusions for the unwary pilot.

A pilot approaching an uphill runway may think he is too high, and if he corrects for that illusion may get too low. The reverse applies if the runway slopes downhill. The pilot may think he is too low, and may end up too high if he corrects.

Runways of a different width than the pilot is used to can fool the unwary pilot in the same way. A normal approach angle onto a wider runway may appear too low, and that onto a narrower runway may appear too high.

Glider pilots will be able to avoid these problems if they ignore the perspective (but not the slope!), but fly to an aiming point just short of the touchdown point at the correct airspeed and angle as they are trained to do. In fact this is the exact technique recommended for bush and agricultural pilots using short, sloping, and sometimes “one-way” airstrips.

RESPIRATION IN THE AVIATION ENVIRONMENT.

Respiration is so important in our discussion that we will treat it as a separate topic. Respiration is the process whereby oxygen, which is essential to the proper functioning of all body cells, is ingested into the body from the atmosphere by the lungs, transferred into the bloodstream, and transported to each individual cell in the body to be converted into energy and other things necessary for life. The process is usually automatic (involuntary) so that the unwary may take it for granted.

At the end of the air passages in the lungs are the alveoli – about 300 million minute air sacs. The alveoli are surrounded by fine capillaries carrying blood. The walls of the alveoli are very thin and semi-permeable. There is a pressure gradient across them, which allows oxygen to pass into the blood and carbon dioxide to come out of the blood into the alveoli. Once in the blood stream the oxygen is able to combine with hemoglobin, and in that form is able to be transported in the bloodstream to all cells of the body.

How much oxygen do we need?

A certain amount of oxygen is essential for the proper functioning of the human body. The air we breathe is a mixture of gasses. Gas Composition by Volume is–

- Nitrogen 78%
- Oxygen 21%
- Others 1%

The 78% of the air that is nitrogen plays no part in the respiration process, which depends entirely on the amount of available oxygen. The ratios of oxygen to the other components of the air we breath remains constant at the altitudes we operate gliders, but pressure of the air reduces with altitude. As a general rule of thumb total pressure of the air has halved by 18,000 ft and again by 34,000 ft. By Dalton’s Law (the law of partial pressures) the total pressure of a mixture of gases is equal to the sum of the partial pressures of the individual

component gases. The partial pressure is the pressure that each gas would exert if it alone occupied the volume of the mixture at the same temperature. So the actual amount of oxygen available reduces with altitude in the same proportion as other gases making up the air.

The “standard atmosphere” assumes a sea-level pressure of 1013.25 millibars (or hectapascals), or 14.7 psi; or 760 mm of Hg (Mercury). The partial pressure of oxygen at sea level outside of the lungs is approximately 150 mm Hg (20% of 760). Once breathed into the lungs this partial pressure of oxygen is further reduced to 102 mm Hg because of the continual presence in the lungs of carbon dioxide and water vapour. 102 mm Hg of oxygen is therefore the required partial pressure of oxygen in the lungs for normal human functioning. Any major reduction in the pressure of oxygen available in the lungs will have adverse consequences for normal functioning.

As we climb higher in the atmosphere the actual quantity and pressure of oxygen available for respiration is reduced below the required 102 mm Hg of oxygen. Less oxygen is available to the body's cells and vital organs, especially the brain. Surprisingly, adverse effects of the reduction in available oxygen are not particularly noticeable up to 8000 ft but become critical at 10,000 ft. Above 10,000 ft we must artificially make additional O₂ available by means of an oxygen supply system fitted to the aircraft. This additional (supplemental) oxygen is added to the available air mix to restore the required partial pressure of oxygen in the lungs for proper bodily functioning.

The basic legal requirement for the use of supplemental oxygen in aircraft is that during any time the aircraft is being operated between 10,000 feet and 13,000 feet AMSL for a period of more than 30 minutes, or above 13 000 feet AMSL each crew member and each passenger must use supplemental oxygen. So, you can operate up to 13,000 feet for 30 mins without oxygen but you need to have an operable system available in case you need to use it.

Any passengers carried when supplemental oxygen is required must have been briefed on the normal and emergency use of oxygen equipment installed in the aircraft.

The Civil Aviation Rules prescribe detailed requirements for the type of oxygen and equipment to be used, and for its use.

Hypoxia (Oxygen Deficiency)

Definition.

Hypoxia is a condition of oxygen deficiency in the body tissues sufficient to cause functional impairment. It is dangerous to pilots for a number of reasons, as we shall see. The early symptoms of mild hypoxia may include euphoria, confusion, impaired vision, and poor judgement. If left unchecked and allowed to continue it will lead to loss of consciousness and **DEATH!**

Symptoms and effects of Hypoxia

General

- Euphoria
- Target fixation
- Personality changes
- Loss of self criticism, judgement
- Fuzziness (not dizziness)
- Amnesia
- Lethargy
- Mental confusion
- Sensitivity to heat/cold
- Cyanosis (bluing of extremities)
- Unconsciousness
- Death

Visual

- Decrease in colour perception
- Decrease in peripheral awareness
- Decrease in visual acuity (dimming)

Neuro Muscular

- Clumsiness
- Fine Tremor
- Slurring of speech
- Slow movements
- Hypoxic flap

The insidious effect of hypoxia and the time of useful consciousness.

These are two very important and sobering aspects of hypoxia that should make pilots especially wary.

1. The insidious effect of hypoxia
2. The time of useful consciousness

The time of useful consciousness is the time within which a pilot can remain capable of competently controlling an aircraft.

[HANDOUT APPENDIX XIII – TABLE OF TIMES OF USEFUL CONSCIOUSNESS]

BEWARE THE TRAP! The table (APPENDIX XIII) is great, if you know when to start the timing! These figures are taken from research in a controlled environment. Sitting up there in our glider, we may not know when the leak starts, or the hose kinks or disconnects!

What this table does tell us is that when a failure occurs we have little time to detect it, let alone fix it before we lose useful consciousness. We may end up laughing as our world fades away! We must therefore establish a routine that regularly checks for hypoxia.

Factors influencing the onset, intensity of, or tolerance to hypoxia

- Altitude attained
- Rate of Ascent
- Time at Altitude
- Physical Activity
- Ambient Temperature
- Illness
- Fatigue
- Drugs / Alcohol
- Smoking
- Stress / Workload
- Level of Fitness

Action In The Event Of Suspecting Hypoxia

In Ourselves–

- go on to oxygen and select high flow (BEWARE THE OXYGEN PARADOX – see below)
- check integrity of system; connections, lines for kinks, contents, mask fitting
- extend brakes and trim glider in max rate descent
- Descend to below 10,000 feet.
- tell someone what is happening
- unless absolutely sure of why problem occurred and fixed, return and land
- caution on returning, you will have been fatigued by the incident so don't rush, and listen to advice from the ground

In others–

Where possible, get them to do the above. This may require slow, clear instruction by radio. Remember, they are unlikely to realise they are hypoxic and will be reluctant to listen – assuming they hear you at all! If nearby, watch from a safe distance – their vision won't be too good!

The Oxygen Paradox

This is the temporary worsening of symptoms when oxygen is restored to someone previously hypoxic. It is the result a momentary reflex constricting the arteries to the brain when there is a sudden increase in the amount of oxygen in the blood. The danger is that you may go on to oxygen, look or feel worse, then suspect it isn't working and turn it back off!!

Causes of oxygen deficiency

- Not using supplemental oxygen when it is required.
- Failure to turn on O2 supply
- Poor-fitting mask
- Mask removal
- A system failure
- "Cheating on the O2 supply.

Hyperventilation (Overbreathing)

Hyperventilation is a condition where an abnormal increase in the rate of ventilation (breathing) results in an excess loss of carbon dioxide from the body, which in turn raises the alkalinity of the blood. This change in pH causes a number of adverse effects.

Symptoms of hyperventilation

- Rapid pulse
- Feeling of unreality
- Unpleasant light-headedness, dizziness or faintness
- Tightness or Constriction of Chest
- Numbness or tingling especially around the hands, feet and mouth
- Further anxiety
- Clumsiness and Tremors
- Muscle spasms to the hands if hyperventilation is prolonged
- Fainting in severe cases
- Feeling of Shortage of Breath

Causes of hyperventilation

- Excessive anxiety, worry or fear
- Pain
- Loud noise
- Vibration
- Excessive heat
- Motion sickness
- Hypoxia
- “G” loading

After a collapse from hyperventilation breathing normally returns to normal and consciousness is regained within a minute or so. Whilst hyperventilation in itself is not dangerous and has no permanent adverse effects, it could be dangerous if a pilot who is the only one flying an aircraft succumbs to its more severe effects. Hyperventilation therefore needs to be understood and avoided, or treated early if it occurs.

Treatment of hyperventilation

- Slow down the breathing 12-16 times / min (Do Not Hold Your Breath!!)
- Take shallower breaths
- Provide reassurance
- “Re-breathe” CO₂ by breathing into and out of a rolled up newspaper or paper bag for a period. Cupped hands may assist if no suitable receptacle is available.

Remember, the hyperventilation may be a symptom of hypoxia!, but this is unlikely at lower altitudes. If there is any doubt at all whether a pilot is hyperventilating or is hypoxic, then they should be treated as for hypoxia (administer O₂ or descend to below 10,000 ft AMSL). Whereas a person who is hyperventilating will not be harmed if they are given 100% oxygen to breathe, telling a person who is hypoxic just to slow their breathing could be fatal to them!

PRESSURE CHANGES

Ascent (decreasing atmospheric pressure)

Trapped gases.

Whenever there is a drop in air pressure outside of a closed cavity with flexible walls, any gas trapped in the enclosed cavity will tend to expand as the pressure

differential across the wall takes effect. According to **Boyle's Law**, at a constant Temperature if you halve the pressure of a gas, the volume will double. This influences what happens to trapped gasses in our bodies when we gain altitude.

There are several areas in the human body where gases are present and can be trapped when a person ascends. The main ones are–

- the stomach
- the intestines
- the middle ear
- the sinuses
- The teeth

The stomach

The stomach and intestines seldom poses any problem on ascent as there is usually ample room for the gases to expand. A little discomfort may sometimes be felt, however.

The middle ear

Gases trapped in the middle ear behind the eardrum can usually escape through the eustachian tubes, provided they are open. Normal rates of climb cause few problems provided the eustachian tubes are open.

The sinuses

Gases trapped in the sinuses can cause pain on ascent if they are constricted, as there little room in them for expansion. Normal rates of climb present few problems.

The teeth

Gas trapped under a filling or in deceased pulp can expand and cause pain when pressure is reduced. Fillings have been known to dislodge!

Treatment–

- Pain is normally relieved on landing
- Take pain relief
- Visit your dentist

Descent (increasing atmospheric pressure)

On descent any trapped gases will contract, tending to create a vacuum unless the pressure differential can be equalised.

The middle ear

[HANDOUT APPENDIX XVII – PICTURES OF THE EAR]

Ear pain on descent can be a common and severe problem if the eustachian tubes are blocked. The eustachian tubes may be unblocked by swallowing, moving the jaw, or by using the valsalva manoeuvre³.

Severe problems which may result are pain, damaged eardrum, loss of hearing, or infection of the inner ear.⁴

The sinuses

Sinus pain on descent is not easily relieved, but fortunately is not common unless the sinuses are constricted due to inflammation or infection. Any resulting pain can extend from the cheek to above the eyes.

Flying with a cold is not recommended because it may prevent you clearing your ears or sinuses.⁵

Nitrogen and “the bends”⁶

About 80% of the earth’s atmosphere is nitrogen. It is not required for respiration, but may be found in solution in the body organs and bloodstream. Dissolved gases such as nitrogen do not pose a significant problem for pilots below about 10,000 feet, but in prolonged flight above 18,000 ft problems could well occur, with the likelihood of problems becoming quite strong above 25,000 ft. Under these conditions a pilot may suffer “the bends” just as underwater divers may if they ascend too quickly in the water having been at depth for lengthy periods. Pilots, however, are not as susceptible as divers as the relative pressure changes they are subjected to are much less. A diver ascending to the surface from a depth of 30 metres undergoes a pressure change of 3 atmospheres, whereas a pilot ascending to 18,000 ft would experience a pressure change of less than ½ an atmosphere!

Pilots flying too soon after scuba diving are especially susceptible to the bends, and could expect symptoms of greater severity and at much lower levels than had they not recently been diving. A good “rule of thumb” is to allow at least 24 hours between the last dive and flying. A delay of 48 hours would be wise if the dive depth has exceeded 35 meters (120 ft) or if the flight is to be above 8000 ft AMSL.

The problem is that with the decreased air pressure at altitude the nitrogen in the body organs and bloodstream comes out of solution and forms gas bubbles. These bubbles are then free to move about the bloodstream and become lodged in the joints, the brain, spinal chord, and under the skin causing a variety of

³ A “valsalva” is performed by pinching the nose, tilting the head back slightly and momentarily pressurising the throat by forcing air up from the lungs, causing the ears to “pop”.

⁴ See “Colds and Flu”, *post*.

⁵ See “Colds and Flu”, *post*.

⁶ Sometimes known as “decompression sickness” or “dysbarism”.

symptoms. A severe attack of “the bends” can cause serious and permanent problems.

Symptoms of “the bends”

- Joint pains
- Itchiness
- Numbness
- Tingling
- Paralysis of parts of the body
- Poor co-ordination and movement
- Mental confusion
- Visual disorders
- Inner ear problems
- Shortness of breath
- Tight or painful chest
- Painful coughing
- Unconsciousness in severe cases

Treatment of “the bends”

Urgent compression in a dive chamber is imperative. Anyone with the bends being transported by air to a dive chamber must NOT be flown at a cabin altitude above 500 ft AMSL as this would seriously aggravate their condition.

BALANCE AND ORIENTATION

Definition of orientation and introduction

“Orientation”, sometimes called “spatial orientation”, is basically the ability to know which way is up, or where we are positioned in relation to the sky, the ground, or the surface of the water we may be in.

For human beings on the ground it is very much a part of everyday life – a largely automatic process which we take for granted. Not much thought is required, for example, to detect whether at any given moment we are standing up or lying down; whether we are at rest or moving, accelerating or turning. The human body has developed the visual system in conjunction with other movement sensors in the body to enable us to orientate ourselves when necessary. Vision plays a large part in this process. At least 80% of the orientation information received by the brain comes from the visual system.

In our normal earthbound environment we have our feet on the ground or on some other object, we are under a vertical gravitational force of 1“g”, and are not moving very fast. We can easily confirm our position visually by reference

to the earth's horizon, or if that is not visible, by buildings or houses which our experience tells us are normally built with their walls vertical.

In the flying environment, however, things can go wildly awry. We may lose our visual reference, or may have to cope with a wide range of speeds and accelerations (“g” forces) ranging from negative values to up to + 5 for glider pilots. The structural design of many gliders will not allow you to exceed about 3 or 4 “g” in any case.

The balance and orientation mechanisms of the body

The balance and orientation systems of the human body consist of–

- The visual system
- The “balance” organs
- The pressure/stretch/position nerve system

The visual system

The importance of vision in orientation has already been noted and stressed (80% of the brain's orientation information). It remains just as important in the aviation environment as it does on the ground. We as pilots learn from the very beginning of our flight instruction to fly an aircraft by attitude, visually comparing its position with the earth's horizon. We learn turns, speed ranges, straight and level flight, stalls, and even aerobatics using the same visual reference. A pilot hoping to fly without this visual reference must rely on artificial aids such as flight instruments, and must undergo special training to accomplish this safely.

The balance organs

There are two main “balance” organs in the human body, both contained in each inner ear in an area about the size of a pea. They are (1) the **semicircular canals**, and (2) the **otolith organs**.

1. *The Semicircular Canals*

The Semicircular Canals are three fluid-filled tubes mounted at right angles to each other to sense acceleration of the head (and therefore the body) in three planes of movement. Once the acceleration has stopped they cease to sense it. A steady-state turn for instance will cease to be detected, and this can lead to disorientation problems such as “the leans” (see below). Although sensitive, the semicircular canals have a threshold to cut out minor accelerations. Thus sub-threshold stimulations or accelerations can go undetected, leading to disorientation problems if they are suddenly detected, or if they are misinterpreted.

“The leans” is a strong sensation of being in one attitude when all the flight instruments are in a different attitude. An extreme example is the “somatogyral illusion”, where the pilot believes the aircraft is in a dive with the wings level, but in fact the aircraft is in a dive with bank applied. The turning

of the aircraft has gone completely undetected by the pilot, and if the pilot tries to pull out of the dive with elevator matters are only made worse. This is the “graveyard spiral”. Pilots must learn to trust their instruments rather than body sensations in this situation.

(ii) *The Otolith Organs*

The Otolith organs are located near the semicircular canals in each ear. They each consist of a tiny jelly-like mass perched on “stilts” of a group of vertical hairs. They sense both head or body tilt and longitudinal acceleration.

The otoliths can give erroneous information. In particular they can misinterpret a forwards acceleration as a steep climb, with disastrous consequences if a pilot attempts to correct a steep climb that is not there near the ground.

The pressure/stretch/position nerve system

This system is a network of nerve receptors distributed around the body which, as the name suggests, detect pressure on the body, muscle stretch, and limb position. Clear examples are pressure on the soles of the feet when standing, pressure on the buttocks when sitting. If you lie down with an arm underneath your body, your brain knows exactly where your arms is in relation to your body even with your eyes closed because of this system.

Like the balance organs, care should be taken not to rely on these systems alone, as they can mislead. For instance, “seat of the pants” pressure centres of the body cannot distinguish between a +3g loop or a +3g steep turn.

Eye / Balance Interaction

There is a strong reflex connection between the eyes and the balance organs called the oculogyral reflex. It enables accurate visual tracking of objects even when the body and head are moving about quite rapidly or erratically.

The oculogyral reflex can be seen in action in this simple demonstration.

1. Hold your thumb up vertically at arm’s length and focus on the thumb nail. Move the thumb around erratically and try to keep the eyes focussed on the nail. (Very difficult!)
2. Next, hold the thumb still but move the head around erratically while trying to keep the eyes focussed on the thumb nail.

Disorientation

A person on the ground will not often become disorientated, as all three balance and orientation mechanisms are generally working together to confirm the information that each is passing to the brain. In the flying environment, however, there is a high potential for confusing and conflicting input of information to the brain. A pilot is said to be disorientated if he or she cannot ascertain their actual orientation in space. A good example for our purposes is

loss of good visual horizon reference on which most of us heavily rely. If we lose that important orientation tool for long, and attempt to rely on other senses (the “seat of the pants” or “the feel of things”) without proper training in the use of flight instruments the results can be catastrophic.

Stay VMC unless you can fly IMC! 180 seconds is all you will usually have before loss of control!

There are two main types of disorientation–

- (i) Those where the pilot is aware something is wrong; and
- (ii) Those where the pilot is not aware that anything is wrong.

Sooner or later most pilots will experience one of these forms of disorientation. An understanding of the causes of disorientation, some avoidance techniques, and some cures is therefore essential.

Flicker vertigo

A form of disorientation can be caused by flicker vertigo, which may occur when a bright light source in the pilot’s field of vision is being interrupted rapidly and intermittently by some object such as a propeller or rotor blades. Many motorists will have encountered the phenomenon whilst driving along a road where the sun is shining through a row of trees into your field of vision. The flickering effect can be quite distracting., and if prolonged can cause a person to become dizzy and unwell. In extreme cases it could lead to convulsions or a “fit”. Pilots encountering the phenomenon should avert their gaze, use a sun shade, or re-position the aircraft to avoid the effect.

Motion sickness

Motion sickness is more common among passengers and trainee pilots than among experienced aviators. It is caused by prolonged unaccustomed motion of the body which upsets the orientation system. It may begin with a feeling of general unwellness, leading to dizziness, nausea, paleness, and cold sweats. Vomiting may often follow, and if the feeling persists the person may become quite ill.

Motion sickness can be aggravated by anxiety and low cockpit activity levels. It can be alleviated by gaining further air experience as early as possible, thus reducing anxiety and building self-confidence. Keeping fit, resting well, eating sensibly before flight, and avoiding alcohol may help considerably. Pilots should relax while flying, and unless flying IMC through necessity, should keep the horizon in sight whenever possible. Passengers should be given warning of any manoeuvres, and unnecessary maneuvers should be avoided.

Instructors and passenger-rated glider pilots should always bear in mind that the student or passenger should be put at their ease as far as possible by the creation of a relaxed and friendly atmosphere. This will do a lot to reduce the chances of motion sickness occurring. Students should be given as much of the flying as possible, but given short time-out periods to relax if their workload is high or they cease to relax. Students should be relaxed, reassured, and

encouraged as far as possible. No passengers or students should be introduced to aerobatics too soon, or for too long. Instructors and passenger-rated glider pilots should be able to fly smoothly to minimise the chances of motion sickness becoming a problem.

TEMPERATURE AND CLIMATIC CONSIDERATIONS

Heatstroke or heat stress

Exposure to high environmental temperatures is clearly the main cause of overheating or heat stress. The exposure may be coupled with and be exacerbated by the breathing of dry air or oxygen. It may also be exacerbated by wind, exertion, dehydration, or fatigue. The prevention of heat stress, and its related condition, dehydration (see next), is particularly important for glider pilots, particularly on long flights because of the physical design of cockpits, and the limited capacity for carrying on-board food and drink. Glider flights often demand high levels of concentration, and take place in weather where temperatures are generally high.

Heatstroke occurs when the body's internal temperature control system gets overloaded. The body will respond to high temperatures by firstly pumping extra blood to the skin, and then by using sweat glands to produce sweat which cools the body by evaporation of moisture on the skin. In extreme conditions of high humidity and high temperatures the body may have trouble dissipating enough heat by these normal methods, and body temperatures can then quickly rise to dangerous levels.

Mild attacks of heatstroke can result in nothing more than a heat rash, muscle cramps, or headache. But if an attack is more severe, or if a mild attack is allowed to deteriorate into a severe condition, confusion, disorientation, or hallucinations may result, as may collapse and even death. If the body is dehydrated then it may stop sweating altogether. If this occurs you have a real medical emergency that requires immediate medical attention.

Precautions against heatstroke

Susceptibility to heatstroke may depend on your underlying physical condition, how dehydrated you have become, and whether you have had time to acclimatize to the sudden increase in temperature. Certain precautions can be taken to guard against the unexpected onslaught of heat stress, such as—

- Drink plenty of fluids, avoiding diuretics such as alcohol and caffeinated beverages.
- Always wear a hat when exposed to the sun (essential for glider pilots)
- Wear loose fitting clothing which allows air to circulate around the body.
- Wear clothing which shields the skin from direct exposure to the sun.
- Keep the body cool as far as possible by proper ventilation or shading.

Symptoms of Heat Stress

The symptoms of heat stress may be severe, and may include–

- Heat rash
- Muscle Cramps
- Headache
- Nausea (and vomiting)
- Dryness of mouth, nose and eyes
- General dehydration
- Poor concentration
- Drowsiness
- Weakness
- Lethargy
- Slurred speech
- Confusion
- Disorientation
- Hallucinations
- Total collapse (or, in extreme cases death)

Any of these symptoms may be so bad as to preclude a pilot from maintaining proper control of an aircraft.

Summary of measures to prevent heatstroke or heat stress.

- Ensure the body is fit, and properly watered and hydrated.
- Wear a sun hat.
- Attempt to control the environment with good ventilation and sensible clothing.

Dehydration

Dehydration is related to heat stress, and may have many of the same symptoms in severe cases. It results from a severe imbalance of water content of the human system which can severely impair human performance. Causes are the same as for heat stress, with the added factor of perspiration of a glider pilot in a hot cockpit environment.

Prevention and treatment of dehydration.

The development of severe symptoms of dehydration of a pilot in flight can have catastrophic consequences. Prevention should therefore be the aim.

Dehydration is best prevented by the frequent intake of suitable cool fluids; you need at least 250 mls/hour to cover fluid lost through respiration alone! 500-600 mls/hour is recommended for particularly hot days. Glider pilots on long flights in hot temperatures (two hours or more) should always carry at least 2 litres of water on board to cope with any eventuality. A pilot might expect to consume anywhere from 300-500 mls/hour to replace fluid lost through perspiration and to keep the body properly hydrated. The importance of adequate fluid intake for glider pilots cannot be too highly stressed. Even the most experienced pilots can tell stories of suffering from heat stroke or dehydration, and the effect this can have on their ability to properly fly an aircraft.

Any headache may be meliorated by the taking of an analgesic.

Overcooling

Overcooling may be just as much a problem for pilots as overheating. The direct cause is low environmental temperatures. Contributing factors include—

- Insufficient Correct Clothing
- Not Protecting all the Body (The greatest heat loss occurs through the head)
- Hypoxia
- Fatigue
- Food- Not enough or the wrong sort
- Anxiety
- Injury
- Recent Illness, Especially Flu
- Wind
- Wet Clothing
- Chills due to perspiration at recent higher temperatures.

Symptoms of Cold Stress

- Uncontrolled shivering
- Signs of tiredness
- Clumsiness – poor co-ordination
- Irrational behaviour
- Lack of interest,
- Lethargy
- Slurring of speech
- Visual problems

HEARING

Little need be said about hearing in this course as it relates to gliding. There are a number of issues which confront power pilots that are not applicable to gliding.

Suffice it to say that good hearing is essential to safe flight operations if there are passengers, or if a radio is being used in the aircraft. In gliding good hearing is also extremely useful in listening to airflow noise and to any airframe aberrations that may develop. Any pilot should take care of his hearing by avoiding exposure to damaging noise at any time, and avoiding infections of the ear as far as possible.

MENTAL AND PSYCHOLOGICAL FACTORS

The psychological and mental “profile” of the ideal pilot.

It is difficult to define what makes a good pilot. It is far easier to list some characteristics of what makes a bad pilot. Modern aviation psychology as applied by air forces in the psychological “screening” and personality testing is able to throw some light on this process, and give some basic “rules of thumb” which are as applicable to voluntary sports aviation clubs as they are to the military. It is important for a safety perspective for club officials and all responsible members of these organisations to have a basic understanding of the role that pilot personality can have in safe aviation practices.

People who are erratic or reckless in their personal behaviour generally do not make good pilots. “Bad” pilots may be over confident, “show-offs”, slapdash, impulsive, careless, complacent, dogmatic, timid, arrogant, inaccurate, poor communicators, unable to think ahead, lack awareness and judgment, be reckless or foolish, or be rough on aircraft and equipment. All of the “good” pilots in this club should be alert for the “bad” pilots who will usually require close watching or special attention if they are to develop into “good” pilots and continue flying!

“Good” pilots, on the other hand, display good airmanship at all times. Airmanship may be defined as the display of good common sense, good aviation practices, and high standards in the air. They not only have good flying skills, but other personality attributes which, if not innate, can be learned or developed. They will be confident, consistent, safe, calm, dependable, knowledgeable, and flexible with good decision-making skills. They learn by experience and the experience of others, and they know their own limits and never exceed them. They always set a good example, and are willing to assist others in achieving their own high standards. They generally do not have incidents or accidents that are a result of bad actions or faulty decisions by the pilot. They stay out of trouble.

Psychological Impairment

Psychological factors such as attitudes to safety, pilot personality, human learning mechanisms, mental capacity and workload, may all play a part in the equation, either as the result of innate problems, or of the physical or physiological nature of the aviation environment.

Mental Capacity Generally

When a pilot is first learning to fly (or drive a car) the mental workload and flow of information to the brain is high. The brain will be working to near full capacity, and therefore any residual capacity for making decisions or handling any new tasks or problems (including emergencies!) is low.

As a pilot becomes more experienced (and many tasks become more automated) residual mental capacity is increased, allowing more accurate flying and improved situational awareness. More prompt and better decisions, even in times of complex tasks or activity will be possible.

Impairments To Proper Mental Performance

Overload of activity or information.

The human brain can easily become overloaded with too much activity or information. Performance suffers as normal functioning breaks down and load-shedding automatically occurs. In this state some information or tasks may be neglected, and accidents may follow. Interestingly, if mental activity (arousal) is too low, a decrease in pilot performance may also result.

[HANDOUT APPENDIX XIV FOR A GRAPH OF PERFORMANCE AGAINST LEVELS OF MENTAL ACTIVITY (AROUSAL)]

Stress and fatigue

Stress has been defined as “The non specific response of a human to any demands for change”. Another definition might be “an excess of environmental demands over an individual’s capacity to meet them.” The demands can be real or imagined – the effect on the human body is the same. Too much stress leads to a “general adaptation syndrome”, and then to eventual collapse.

Some stress is perfectly normal, and is in fact essential to human survival. Our bodies are built for stress and strain. Even getting out of bed puts some demand on the body! Stress is therefore a normal part of living, working, relating and succeeding. Only the comatose and the dead do not experience stress from time to time in their daily lives.

How Much Stress is Normal?

Obviously we like to vary our diet of stimulation and like some times of excitement and some times of relaxation. While a good balance is maintained, few people have problems with stress. However, many people do not keep or achieve a good balance between effort and recreation. It is obvious that those

involved with gliding should be able to recognise the signs and symptoms of stress that take us beyond our comfort zone and degrade our performance and jeopardise our safety and efficiency. By learning to recognise the signs we can develop means of managing stress and minimising possible negative consequences.

Stressors

Factors which cause stress are called stressors. The capacity of individuals to meet the demands of stress will vary considerably, and what stresses one person in a given situation will not necessarily stress another. However the individual handles a particular stressor, there will be some physical, mental and emotional reaction. Too much stress or arousal is not good for a pilot, but neither is too little. There is an optimum amount of stress for best human performance, and a level above and below this amount will decrease performance. (See Handout Appendix XIV, “performance/arousal curve” above). A pilot may be subjected to two main types of stressors, direct and indirect.

(i) Direct stressors

As the name suggests, direct stressors are those resulting from the immediate task of flying an aircraft. Direct stressors (flying-related) may arise from such things as glare, turbulence, weather, time delays, unexpected mechanical, air traffic control, or navigation problems, temperature extremes, dehydration, hypoxia, visual illusions, disorientation, fatigue, lack of fitness to fly, or ergonomic factors.

(ii) Indirect Stressors

Indirect stressors may relate to the pilot's normal domestic environment such as personal, family or relationship problems, financial concerns problems, or job satisfaction concerns. This type of stressor is cumulative, that is they all “add up” to contribute to the total stress at any given time.

As long as a pilot's abilities are greater than the demands placed upon him or her, stress should not become a problem. If the demand exceed abilities, then a stage is reached where the chances of an accident become quite high. It is important therefore that pilots should not attempt anything which is beyond their capabilities.

Signs and symptoms of stress.

When subjected to stressors we are put in a stressed state which invokes a variety of possible responses.

A person may make mistakes, become short-tempered, forget important tasks, start smoking or smoking more, drink alcohol excessively, display noisy or uncharacteristic behaviour, have frequent conflicts with other people, develop marital or relationship problems, fly dangerously or unsafely, or become involved with the law.

More direct symptoms while flying may include nervousness or shaking, anxiety, sweating (esp. forehead or palms of the hands), and over breathing

(hyperventilation). If the stress becomes very acute or severe, the pilot may attempt to compensate, acting out certain non-typical behaviours, for example “tough guy” or “macho” displays in order to hide the stress within. Some sort of “break down” may result.

Prolonged acute stress can have long term physical manifestations such as peptic ulcers, high blood pressure, heart disease, ulcerative colitis and asthma.

Coping with stress.

The best ways to reduce stress and its additive effects are to–

- Keep physically fit and healthy
- Eat well
- Rest well
- Relax well
- Sleep well
- Know your capabilities and keep within them
- Think and plan ahead
- Get organised
- Prioritise
- Delegate and load shed
- Seek assistance where necessary
- Avoid procrastinating
- Understand how stress affects YOU, and do something about it!

Fatigue

A definition of fatigue is the accumulation of stress, usually of unresolved stress building up over a period. Fatigue is usually quite debilitating, and a significantly fatigued pilot will be unable to fly safely.

The main causes of fatigue are lack of good quality sleep, prolonged excessive workload, or too long without adequate rest. Fatigue, like stress, can be exacerbated by the effects of any minor illness, drugs or alcohol. It is chronic stress from heat, cold, hypoxia, dehydration, hunger, sleep disturbances, new operating environment and weather conditions that are the most common causes of fatigue for glider pilots.

Signs and symptoms of fatigue.

The symptoms of fatigue are similar to those of excessive stress.

- reduced visual field
- drowsiness
- we suffer channelised attention

- we are easily distracted or can be pre-occupied
- our judgment erodes
- we become careless and take unnecessary risks
- we lose our sense of timing
- our coordination deteriorates
- we become forgetful
- our reaction times increase
- we may accept lower standards
- we are susceptible to illusions
- we become irritable

The effects can be quite insidious and difficult to recognise in ourselves until well advanced. Pilots seem to pride themselves on being able to 'hack it'.

Treatment for fatigue.

Fatigue cannot be overcome quickly. It can really only be relieved by resolving the underlying workload or stress problems, and by allowing adequate rest and sleep. An understanding of stress and stress management techniques will also help. These include such elementary steps as better organisation, better management of time and workload, good prioritisation, improved physical fitness and better quality sleep.

“G” FORCES

General

The human cardio-vascular (blood circulation) system is designed to function optimally at a normal “g” force of 1. It is a complex pressure system which is particularly susceptible to the application of extra (positive “g”) or less (negative “g”) forces than this “norm”.

When an aircraft is flying under positive “g” loading (e.g. when flying a ‘loop’) the blood in the pilot’s head is forced downwards towards the stomach and legs. The blood supply to the brain is reduced and therefore the oxygen supply to the brain will be diminished.

Up to about 2½“g” the body can adjust to this effect by means of a reflex known as the “physiologic compensation”, although this compensation takes several seconds to occur.

Application of further “g” however, results in so much blood being drained from the brain that the pilot will progressively suffer the following–

- loss of colour (“grey out”)]
- loss of peripheral vision (tunnel vision)

- blurring of vision (loss of visual sharpness)
- Total loss of vision (“black out”)
- G-induced loss of consciousness or GILOC

Negative “g”

The limits of human tolerance to negative “g” are less than for positive “g”. Under sustained negative “g” a pilot may suffer blood congestion problems with blood having difficulty flowing back to the heart. Oxygen availability to the eyes and brain becomes just as compromised as if there was insufficient blood pressure. The “red-out” described by pilots under negative “g” is probably congested blood collecting in and around the eyelids. Sustained negative “g” is difficult to achieve in a glider, so a glider pilot is not often confronted with great problems with negative “g”. Gliders themselves, as other aircraft, are stressed for much less negative “g” (about half) than positive “g”. Pilots must at all times observe the operating limits of the aircraft they are flying.

Palliative measures

Anti-G straining manoeuvre.

The pilot’s ability to maintain consciousness is related to maintaining blood pressure to the brain. A properly trained pilot may utilise a technique called the anti-G straining manoeuvre, which involves the simultaneous isometric straining of the muscles of the upper and lower legs, stomach, upper chest, neck and shoulder muscles, while still breathing! Clearly this technique requires special training, and must be done correctly for good effect. The maximum “g” tolerance that an experienced pilot can sustain without an anti-G suit is between 5 and 6g. This will be more than most gliders can tolerate in any event!

Anti-G suits.

An anti-G suit is usually a pair of trousers with automatic G-controlled inflatable bladders built into them to exert pressure against the legs and abdomen. These areas of the body are squeezed during the application of “g” forces, thus reducing the pooling of blood in this area of the body by a kind of tourniquet effect. An pilot experienced in the use of an anti-G suit may increase his tolerance of “g” force to about 9g.

Factors affecting “g” tolerance

Factors ENHANCING “g” tolerance.

- Recent frequent exposure (practice)
- Weight training
- Body position

- Anti-G straining
- Anti-G suits
- Being short
- Being female

Factors REDUCING “g” tolerance.

- Lack of recent exposure
- Fatigue
- Illness (dehydration, hangover, drugs, hypoxia)
- Heat stress
- Hyperventilation
- Low blood pressure
- Being male
- Being tall

ADVERSE MEDICAL FACTORS

Drugs and alcohol

Illicit drugs

Needless to say, the piloting of an aircraft while under the influence of any illicit perception, mood, or performance altering drugs such as opiates, LSD, cannabis or amphetamines is absolutely prohibited for all pilots.

Alcohol

The effects of alcohol on a pilot’s performance should never be under-estimated, and it can last for many hours after the last glass has been consumed. While the consequences of excessive alcohol intake on performance are well known, most people are less aware that their performance can be impaired long after their blood alcohol concentration returns to zero. For that matter, even low or moderate amounts of alcohol the night before can seriously jeopardise the safety of a flight the following morning. Even though your blood alcohol concentration may have returned to zero you may still suffer from less-publicised after-effects, of alcohol use such as fatigue, nausea and headache.

Effects of alcohol

- Poor performance generally
- Disorientation
- Dehydration

- Increased susceptibility to “g” forces
- Increased susceptibility to hypoxia
- Increased susceptibility to decompression sickness (the bends)
- Interference with temperature regulation of the body

General effect on performance.

The immediate effects of alcohol on performance, particularly orientation perception and judgment, are well-known, but are worth examining again briefly here.

Orientation in flight depends on three basic mechanisms–

- Sight
- balance (vestibular system)
- 'seat of the pants' feel

Even small amounts of alcohol can significantly impair all of these systems. The impairment of the vestibular system by alcohol will be well known to anyone who has had a big night on the town and woken the next morning to find that even the slightest head movement results in dizziness and the room going into a high velocity spin. This is caused by alcohol entering the semicircular canals, which are responsible for sensing angular movements of the head. The alcohol dilutes the fluid in the canals, reducing its density by a considerable degree, meaning that with any given head movement the fluid will travel further and faster, resulting in exaggerated signals of head movement being sent to the brain. This phenomenon is extremely disorientating on the ground, but it is much worse in the three-dimensional environment of flight.

The Coriolis phenomenon is a severe tumbling sensation brought on by moving the head out of the plane of rotation, simultaneously stimulating one set of semicircular canals and deactivating another set. Even modest amounts of alcohol can induce this effect with even the slightest head movement while flying, causing significant tumbling feelings and disorientation. This is particularly dangerous in IFR flight, which is made significantly more difficult by this phenomenon. The effect of alcohol on the vestibular system can persist for up to **several days** after blood alcohol levels have returned to zero.

Nystagmus affects the visual system and is described as a series of involuntary oscillatory eye movements generated by stimulation of the semi-circular canals. Nystagmus can be caused by spin recoveries, and its symptoms are amplified, in severity and duration, if there is alcohol in the system. Pilots suffering from nystagmus find it extremely difficult to focus on either the outside world or the instrument panel. The disorientating potential of such a situation is quite marked, and it can lead to complete loss of control of an aircraft. Nystagmus can be demonstrated up to 11 hours following the intake of a single dose of alcohol.

The Hangover

Hangover includes symptoms such as headache, gastrointestinal disturbance, impaired mental ability, and fatigue. It can seriously degrade a pilot's performance, even if the blood alcohol level is zero. This is well illustrated by a study in which pilots flew a simulator profile 14 hours after achieving a blood alcohol level of 0.01 per cent. Their procedural error rate was 68 percent.

The general feelings of ill-health during the hangover period also have a negative effect on the performance of the pilot. For example, the headache is at best a distraction, but it can be severe enough to effectively incapacitate the pilot and limit his or her ability to control the aircraft safely.

The hangover syndrome can last 24 to 48 hours (depending on the amount of alcohol consumed in the intervening period).

Alcohol-related fatigue

Alcohol is a widely used and readily available aid to sleep. The problem with alcohol is that it interferes with normal sleep patterns. This results in poor quality sleep, even though the total hours of sleep may be in the normal range. The reason for this is that alcohol promotes early deep sleep and suppresses early REM (rapid eye movement) sleep, the phase in which dreaming occurs. This can occur with quite small doses of alcohol, that is, with blood alcohol concentrations as low as 0.025 percent. Larger doses may suppress REM sleep altogether. The change in sleep patterns or the deprivation of REM sleep causes subjective feelings of tiredness and impaired concentration the next day.

The news is not all bad however. Because the body will metabolise alcohol at the average rate of one standard drink per hour, alcohol can be safely consumed with an evening meal for example, providing enough time is allowed for your blood alcohol concentration to drop. The best target is to have a blood alcohol concentration of 0.0 percent before lights out!

This point is worth emphasising – a nightcap just before retiring to bed may make you feel more fatigued and less alert the next morning. Alcohol also has a number of other effects on sleep. It causes early morning waking, and the diuretic effect may also promote a number of awakenings during the night as the requirement to empty one's bladder at frequent intervals becomes paramount. Alcohol will also accentuate the effects of jet lag. A few drinks after a flight across several time zones will certainly not help recovery from jet lag, and it may in fact make the situation worse by degrading the quality of any sleep that the pilot manages to get.

The dehydrating effects of alcohol

Alcohol in our system dehydrates us, and causes the excretion of electrolytes, minerals and salts.

Effect of Alcohol on tolerance to "g" forces.

Of importance to acrobatic pilots is the fact that alcohol reduces tolerance to g. Some studies have shown that even a moderate level of alcohol will reduce the

“g” tolerance of the pilot by approximately 0.5 g. Alcohol relaxes smooth muscle and allows the veins and arteries to dilate.

When “g” is applied, a greater percentage of the pilot’s blood volume is driven to the lower body – *away from the head*. This effect is made worse by the dehydrating effect of alcohol, which reduces blood volume. Less overall blood volume and a greater percentage of blood heading into the legs will reduce tolerance to positive “g” and increase the risk of G-LOC (G-induced loss of consciousness). Increased levels of “g” also tend to exaggerate the nystagmus induced by alcohol, a situation that can persist for some 48 hours.

Effect of Alcohol on tolerance to hypoxia.

The presence of alcohol in the blood stream and organs impairs the metabolism and utilisation of oxygen.

Conclusion re alcohol.

Alcohol has a number of persistent effects that can negatively impact on flight safety. There are significant problems in flying during the hangover period, and, as shown above, even flying the morning after a few drinks the night before may not necessarily be the safest option. Adherence to a simple bottle to throttle rule does not guarantee maximum performance in the air. As safety-conscious pilots we should only fly when we are mentally and physically fit. In some cases that may mean not flying the morning after the night before.

CAA Rules state:

1. No operating an aircraft if your capacity may be impaired by the effects of drugs and/or alcohol.
2. No passenger who is under the influence of drugs and/or alcohol is to be carried

Blood sugar levels

The body needs a ready supply of sugar (glucose) in the blood for energy. Too much or too little in the blood is harmful, so the body must regulate the level within tight limits. This function is performed by the pancreas, which secretes insulin into the blood stream whenever blood glucose levels are too high.

High blood sugar

If insulin from the pancreas is insufficient or ineffective high glucose levels in the blood will result. If undetected or untreated this can lead to diabetes, a dangerous condition leading to damage to the small blood vessels of the eyes, kidneys and heart. Severe illness, collapse, blindness, kidney or heart failure can result. In severe cases a patient may be permanently dependent on daily insulin injections or dialysis for survival. Pilots who develop diabetes may have difficulty maintaining a pilot’s licence, although it should be possible to fly gliders solo.

Low blood sugar in the body (hypoglycemia)

This condition can temporarily occur from time to time in normal people. It needs to be understood by pilots as the symptoms can be quite marked, and can interfere with the ability of a pilot to fly safely.

The condition can be brought on if a meal is missed, causing temporary “dips” in normal blood sugar levels. Symptoms can be quite marked, and may include—

- Shakiness
- Nervousness
- cold sweating
- increased heart rate
- faintness.

Symptoms may be exacerbated by a “hang-over”, some other minor illness, or hypoxia.

Causes of hypoglycaemia

- Decreased Intake of sugar or energy foods
- Increased Consumption of sugar by the body.
- Combination of Both
- Missed meals
- Too much sweet too quick
- Illness
- Alcohol or drugs
- Intense workload
- “G” forces
- Fatigue
- Heat or cold stress
- Hypoxia

Effects of hypoglycaemia

- Reduced Performance
- Increased Frequency of Errors
- Greater risk of accidents

Reactive (or “rebound”) Hypoglycaemia

It is important to know that hypoglycaemia can be made worse if a person eats a small candy or chocolate bar (i.e. ingests a small amount of sugar into the body quickly. This will turn on the body’s insulin production, which in turn

reduces the overall blood sugar level still further!, making the original situation considerably worse. Starch or protein food snacks (such as sandwiches with mixed fillings) are preferable to sugary ones if a snack is required in flight.

While rebound hypoglycaemia is rare, its effect can be catastrophic. It can be avoided by the taking of regular, balanced meals (every four hours or so), and avoiding the eating of small sweet foods when it is felt that blood sugar levels are low.

Colds and flu

Flying with a cold is not recommended because it may prevent you clearing your ears or sinuses. Severe colds or influenza-like inflammations can cause headaches or other distracting symptoms. Any illness with a fever can interfere with the normal hydration and temperature regulation of the body.

A cold will make a pilot less able to think and react decisively, particularly in an emergency. A cold will also cause congestion in the nose, sinuses and ears. In particular, a cold can block the eustachian tubes which connect the back of the throat to the inside of each eardrum. A cold may also block the sinuses.

Main effect of blocked sinuses or eustachian tubes or sinuses.

If the eustachian tubes or the sinuses become blocked the pilot will be unable to equalise the pressure inside the middle ear and other head cavities during climbing or descent. This can result in severe pain because of trapped gasses within these cavities. The ascent does not often present a problem for the eustachian tubes, because air can usually escape outwards through the tubes during the climb. During the descent, however, air can often not return into the tubes, causing a vacuum in the middle ear which can result in severe pain, dizziness, and a rupture of the eardrum. If the eardrum ruptures, problems with hearing and unfitness to fly may last for several months or more. Pilots are therefore advised NOT to fly if they have a HEAVY cold.

The valsalva manoeuvre.

A “Valsalva” is performed by pinching the nose, tilting the head back slightly and momentarily pressurising the throat by forcing air up from the lungs, causing the ears to “pop”. If the ears can easily be cleared in this fashion then the pilot is probably safe to fly.

The manoeuvre should only be attempted if the cold is light, or if the pilot is recovering from a cold. This is because in cases of severe cold or sinus infection the infection could be forced up into the middle ear or sinus and worsen the situation.

Hay fever.

Hay fever can cause congestion in the nose and sinuses similar to a cold. Unlike a cold, however, hay fever is treatable with nasal sprays. Only approved steroid nasal sprays should be used, and not anti-histamine pills, which can cause sleepiness and inattention (despite the assurances of manufacturers).

Minor Illnesses

Where a pilot has had a major illness, accident or operation which necessitates recuperation in hospital or at home, or time off work, it is usually perfectly clear that a pilot should also take a rest from flying until good health is regained. Examples of such incapacitating illnesses are angina, heart attacks, asthma attacks, peptic ulcers, kidney stones, lung collapse and diabetes.

But where the medical problems encountered by the pilot are less serious (minor illnesses), the situation is not always so strait-forward. Minor illnesses can be described as any health problem that is troublesome, perhaps intermittently, but is not severe enough to require hospitalization or confinement to bed. These illnesses usually come on quite quickly, and often resolve just as quickly. Examples are coughs, sore throat, colds, flu, mild bronchitis, headache, diarrhea, hay fever, muscle pain, or menstrual problems. In the case of minor illnesses a pilot may sometimes have difficulty in deciding whether or not he or she is fit for flying. Most of these common illnesses can be treated with simple common sense measures. Caution should be exercised about the use of over-the-counter or “natural” remedies (see “medication” below). If there is any doubt about the fitness of the pilot to fly or about the completeness of any cure the pilot should not fly.

There may be occasions when we start out feeling okay but for whatever reason, we get tired or feel unwell. This will certainly undermine our performance and we definitely don't learn when like this. So, speak up early if dual. Your instructor will surely try to take your mind off it while returning to land. An air sickness bag is carried just in case...and many have “been there, done that”, so don't be embarrassed.

Medication

Pilots should be aware that many types of medication for various illnesses may be hazardous in the aviation environment. Some medications have side-effects such as drowsiness. These often contain warnings against driving a motor vehicle for a period after taking them, and are obviously dangerous whilst flying an aircraft. If unsure of the likely effects of any medication you are taking, the safest course is to seek the advice of a doctor, preferably an aviation qualified doctor before flying as pilot in command of an aircraft.

FITNESS FOR FLIGHT

[SEE APPENDIX XV FOR THE “I'M SAFE” (“Am I fit to fly?”) PERSONAL PRE-FLIGHT CHECKLIST].

ABBREVIATIONS

AGL	Above ground level
AIP	Aeronautical Information Publication
AMSL	Above Mean Sea Level
ATC	Air Traffic Control
ATS	Air Traffic Services
ATZ	Aerodrome Traffic Zone
CAA	Civil Aviation Authority
CAR	New Zealand Civil Aviation Rules
CASO	Civil Aviation Safety Order
CFI	Chief Flying Instructor
CMC	Contest Management Committee
CTA	Control Area
CTR	Control Zone
DME	Distance Measuring Equipment
ECT	Evening Civil Twilight (end of daylight)
ELBA	Emergency Locator Beacon – Aircraft
ERC	En-Route Chart
FAI	Federation Aeronautique Internationale
FIC	Flight Information Centre
FIR	Flight Information Region
FL	Flight Level
FRTO	Flight Radio Telephone Operator rating.
FSS	Flight Service Station
GAA	General Aviation Area (incorporates GFA)
GFA	Glider Flying Area
IFG	Instrument Flight Guide
IFR	Instrument Flight Rules
IMC	Instrument Meteorological Conditions
MBZ	Mandatory Broadcast Zone
MCT	Morning Civil Twilight (Beginning of daylight)
MET	Meteorology
Nm	Nautical Mile
NORDO	No Radio
NOTAM	Notice to Airmen
NZAIP	New Zealand Aeronautical Information Publication
NZDT	New Zealand Daylight Time (UTC plus 13 hours)
NZGA	New Zealand Gliding Association Inc.
NZST	New Zealand Standard Time (UTC plus 12 hours)
PDZ	Parachute Dropping Zone
QFE	Atmospheric pressure at aerodrome level
QGP	Qualified Glider Pilot
QNH	That pressure setting which indicates the height of the aircraft AMSL
RTF	Radio Telephone
SAR	Search and Rescue
SFC	Surface
UTA	Upper Control Area
UTC	Co-ordinated Universal Time (the same as GMT)
VFG	Visual Flight Guide
VFR	Visual Flight Rules
VIP	Very Important Person
VMC	Visual Meteorological Conditions
VTC	Visual Terminal Chart

AIRSPACE CLASSIFICATION EXAMPLES

CTA/C

CTA/E

CTR/C

CTR/D

TMA/D

UTA/C

**FLIGHT BY GLIDERS OR POWERED GLIDERS NOT UNDER
POWER IN VMC**

AIRSPACE CLASS	Within Controlled Airspace (C, D, or E)	Outside of controlled airspace (G)	
		Above—	At or below—
		3000 ft AMSL or 1000 ft above terrain, whichever is the higher	
Flight Visibility			
Above 1000' AMSL	8 km	5 km	5 km
Below 1000' AMSL	5 km		
Distance from cloud			
Horizontal	1 Nm	1 Nm	Clear of clouds, and in sight of ground or water.
Vertical	1000 ft (500 ft in CTA/E)	1000 ft (500 ft up to 11000 ft AMSL)	

NB – In IARAs, the normal met minima is 5 km, 1 NM, and 1000'. However, flight is permitted with less flight visibility if clear of cloud, in sight of land or water, and if RTF confirmation of no IFR traffic in the area is confirmed.

BASIC RULES OF THE AIR

Basic give-way rule

When two aircraft are approaching head on or nearly so, each shall alter course to the right (refer also Ridge flying, 3.5).

Overtaking glider to give way

If you are overtaking another aircraft, that aircraft has the right of way.

Landing aircraft have right of way

An aircraft or glider landing or on final approach has right of way over an aircraft or glider in flight or on the ground.

Right of way by aircraft type

Power aircraft are required to give way to gliders, and gliders to balloons and parachutists.

Right of way in the circuit

When two or more aircraft are approaching to land at the same time the one at the lower height has priority. Gliders using dive brakes should not take advantage of this to cut in front of a glider or aircraft on final approach. When two gliders join the circuit at the same height, the glider of higher performance shall give way to the glider of lower performance.

Right of way in an emergency

All aircraft must give way to an aircraft making an emergency landing.

Thermalling rules

A glider joining a thermal must circle in the same direction as any other glider already working the thermal. It must be remembered however, that this does not guarantee a safe separation between gliders, especially if the circles as flown are not concentric. Care must be taken in thermals to ensure that unexpected lift or sink does not bring the glider onto a collision course with another glider.

Ridge soaring

When ridge soaring, turns must always be made away from the ridge. An overtaking glider must pass between the overtaken glider and the ridge. When two gliders are approaching head-on, the glider who can turn right away from the ridge **MUST** do so.

STANDARD PRE-TAKE OFF AND PRE-LANDING CHECKS

The following standard checks are laid down for all gliding operations. The checks must be carried out in the order specified, and each “key” word should be said aloud, each time the check is performed.

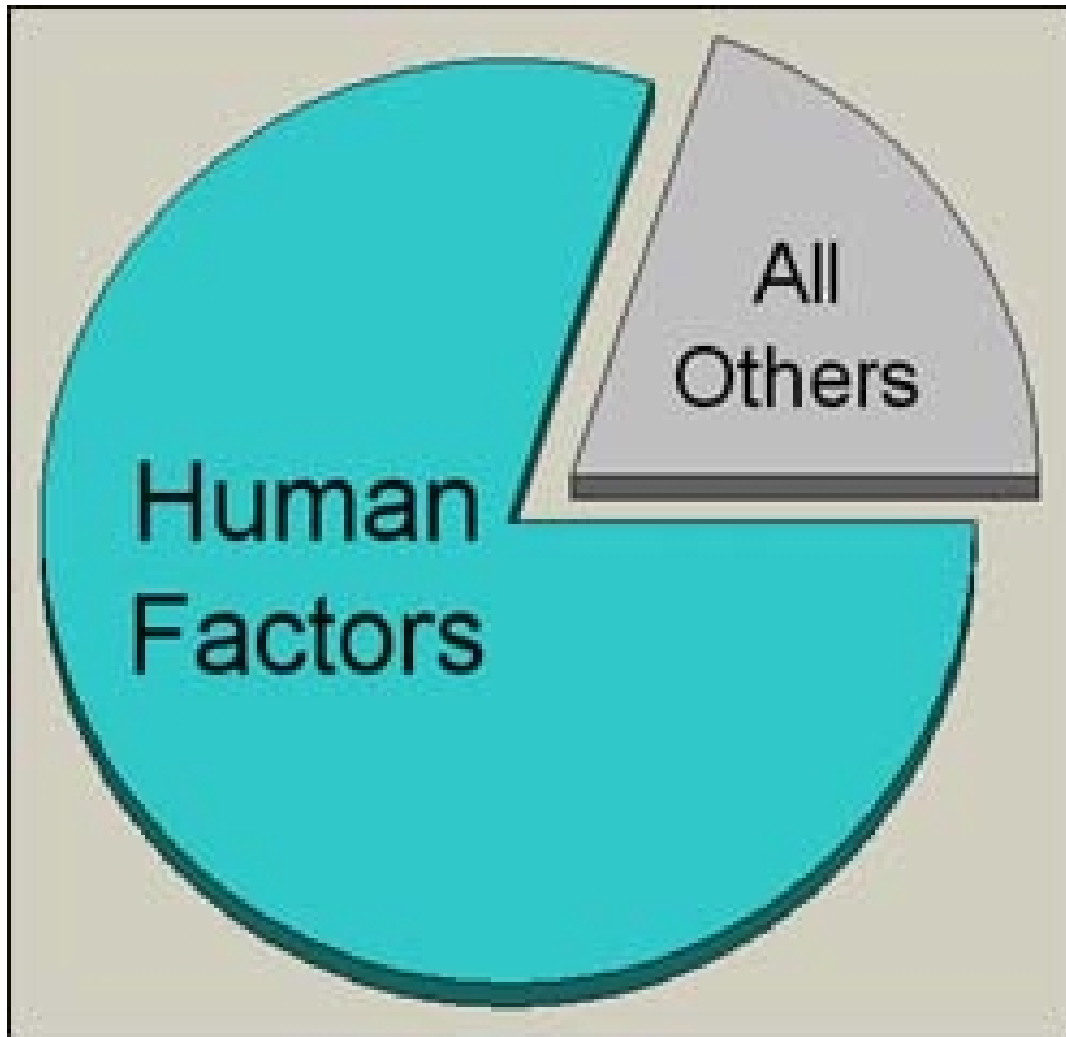
PRE TAKE OFF CHECKS

C ontrols	Check elevator, ailerons and rudder for full free and correct movement.
B allast	Ensure pilot weight(s) plus ballast within placard limits and that any ballast required is fitted and secured.
S traps	Check harness(es) correctly fastened and adjusted.
I nstruments	Altimeter set, other instruments (including barograph, radio and transponder if carried) functioning, no broken glass.
F laps	Full and free movement. Set for take-off.
T rim	Full and free movement. Set for take-off.
C anopy	Check closed and locked, visually. Push upwards on the frame.
B rakes	Check fully open, and even on both sides, then closed and LOCKED.
E ventualities	Review the options and responsibilities for action in the event of a Non-Normal situation on takeoff.

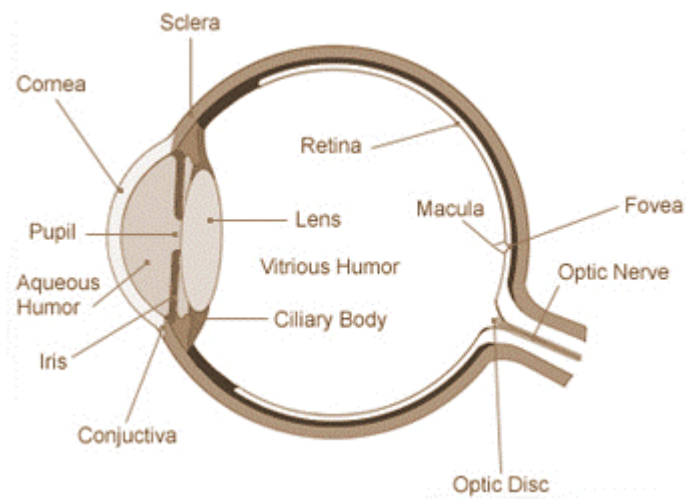
PRE LANDING CHECKS

S traps	Check harness(es) correctly fastened and adjusted tightly.
U ndercarriage	Check down and LOCKED.
F laps	Check set for landing.
B rakes	Check functioning (by brief full extension) then utilise as required.

**PROPORTION OF FLYING ACCIDENTS
CAUSED BY HUMAN FACTORS!**



ANATOMY OF THE HUMAN EYE



VISUAL ILLUSIONS (BLIND SPOT) (NO. 1)



Cover the left eye, and while focussing the right eye on the cross, move the page slowly towards the head and then away from the head. Notice what the eye sees regarding the "dot". Repeat for the

VISUAL ILLUSIONS (BLIND SPOT) (NO. 2)

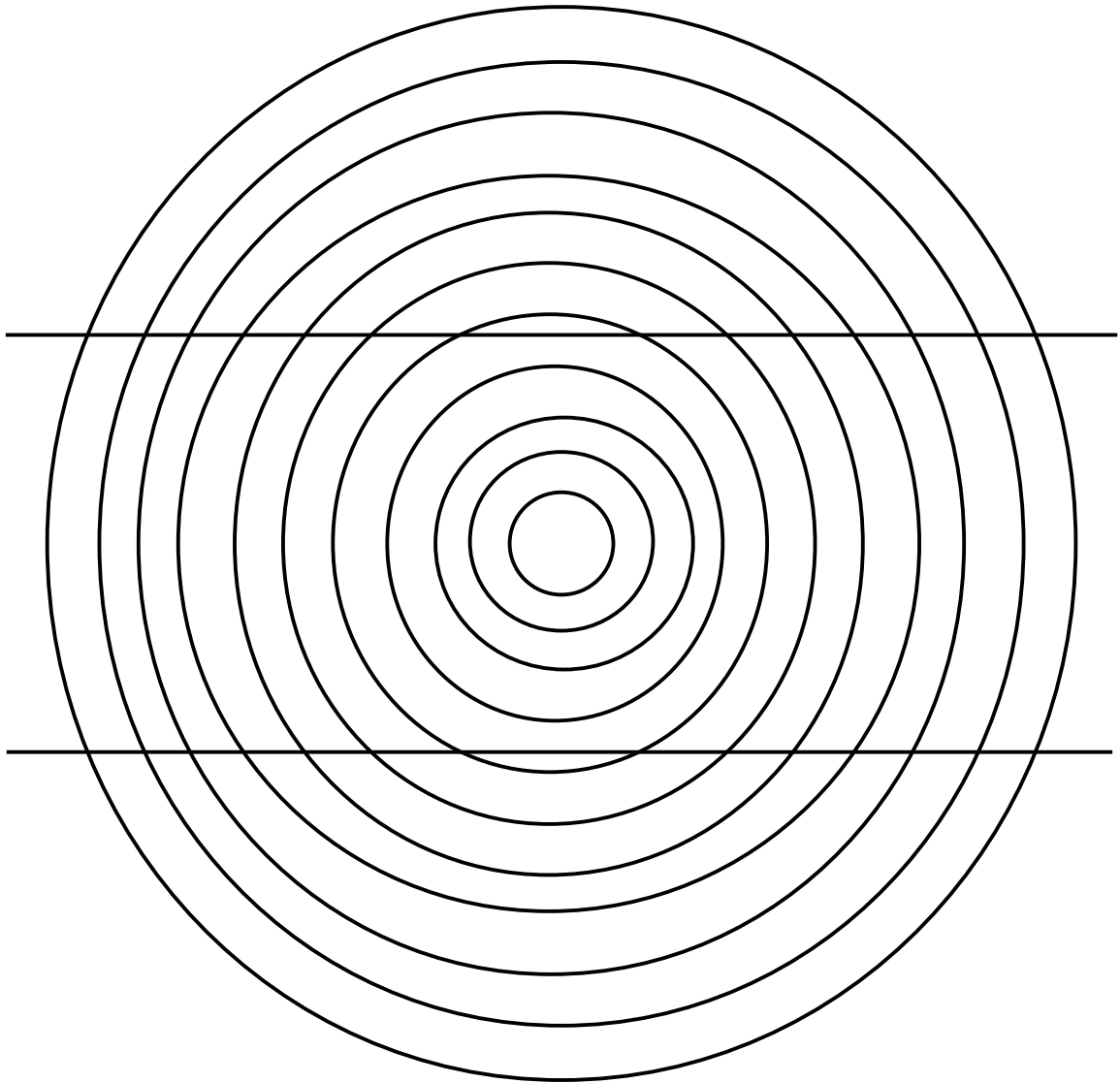


Cover the left eye, and while focussing the right eye on the cross, move the page slowly towards the head and then away from the head. Notice what the eye sees regarding the “gap” in the bars.

TABLE OF TIME LAG BETWEEN LOOKING AND RESPONDING

PROCESS		TIME TAKEN	TIME LAPSE
Looking	Is there something out there?	0.2 seconds	0.2 seconds
Seeing	Yes, there is definitely something out there!	0.3 seconds	0.5 seconds
Recognising	It is another glider... a twin astir!	1.0 seconds	1.5 seconds
Evaluating	It is coming this way...I need to turn, Now!	3.0 seconds	4.5 seconds
Responding	Maneuvering to avoid the collision	3.0 seconds	7.5 seconds

VISUAL ILLUSIONS (LINE BENDING) (NO. 1)



VISUAL ILLUSIONS (LINE BENDING) (NO. 2)

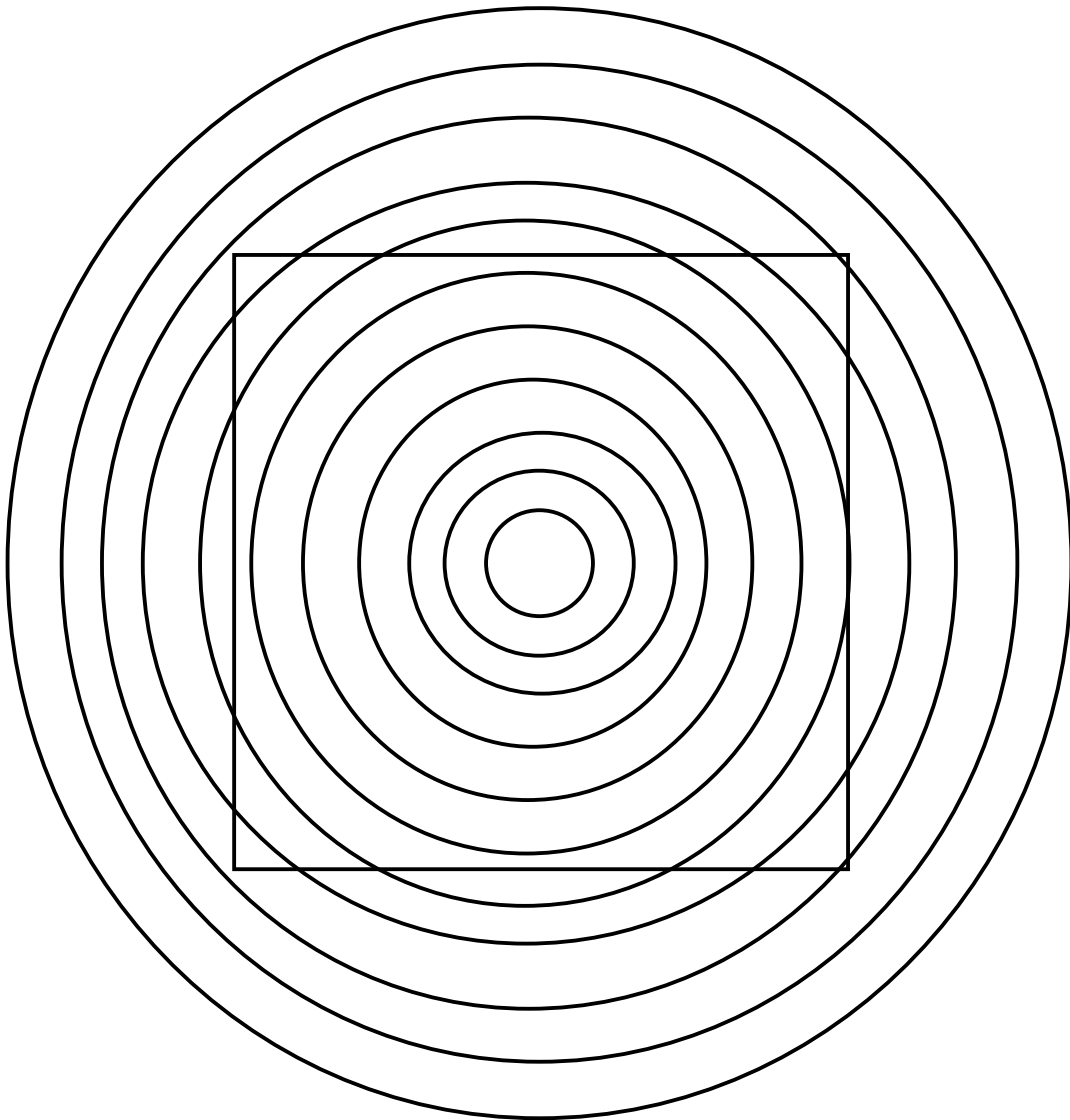
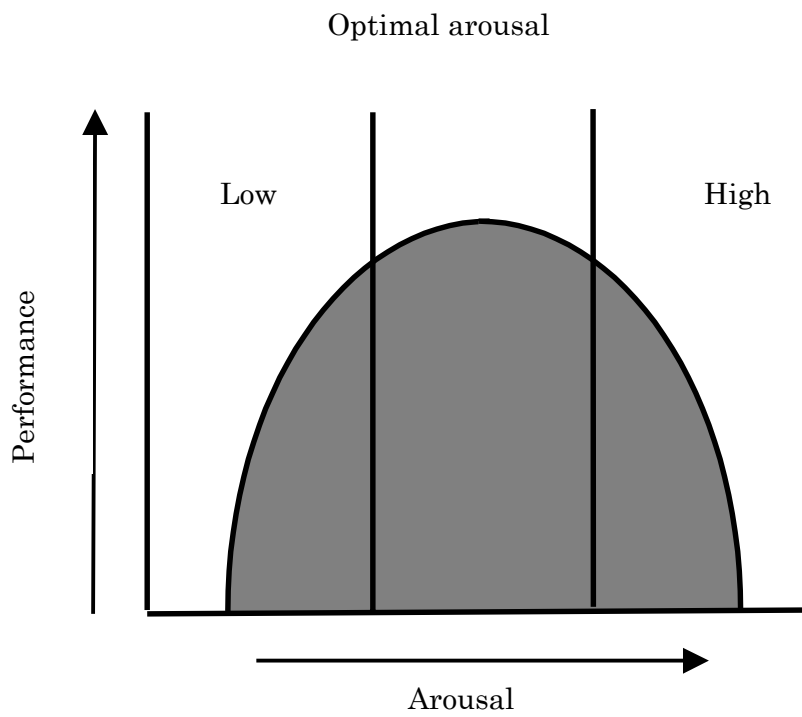


TABLE OF TIME OF USEFUL CONSCIOUSNESS

Time of useful consciousness		
Altitude	Sitting	Moderate Activity
18,000 ft	20 - 30 mins	10 - 15 mins
21,000 ft	10 mins	5 mins
25,000 ft	3 mins	2 mins
28,000 ft	1½ mins	1 min
30,000 ft	1¼ mins	45 secs
35,000 ft	45 secs	30 secs
40,000 ft	30 secs	18 secs
43,000 ft	15 secs	9 secs

**GRAPH OF PERFORMANCE AGAINST LEVELS OF MENTAL
ACTIVITY (AROUSAL)**



“AM I FIT TO FLY?”

– A personal pre-flight “I’M SAFE” checklist –

I llness. We must be free of illness. Most illnesses affect our primary senses and have the potential to cause visual problems and/or balance problems and therefore orientation problems. Ears and sinuses must be clear of congestion to cope with the pressure changes that occur with all flight. Our limbs and muscular system must be fully functional to allow normal control. Don’t be tempted to fly too soon after any illness and ensure you don’t fly if still in bandages that may restrict your full control of the glider!

M edication. Most over the counter medications are not designed with pilots in mind. They work perfectly well on the ground but have hazardous side effects for pilots. The most common undesirable effects are drowsiness and suppression of primary senses. Check with an Aviation Qualified Doctor that any medication you are taking is safe for use as the flying pilot...not just as a passenger.

S tress. There is an optimum amount of stress for humans. Too much and we suffer undesirable side effects like forgetfulness and irrational decision making...not good in an aeroplane! Don’t think going flying is an escape from the stress in your life; it is supposed to be relaxing but you must start free of stress so you can handle anything that may occur during your flying. When flying, remember that the environment we operate in can be very stressful in terms of extremes of heat or cold, so dress and prepare appropriately.

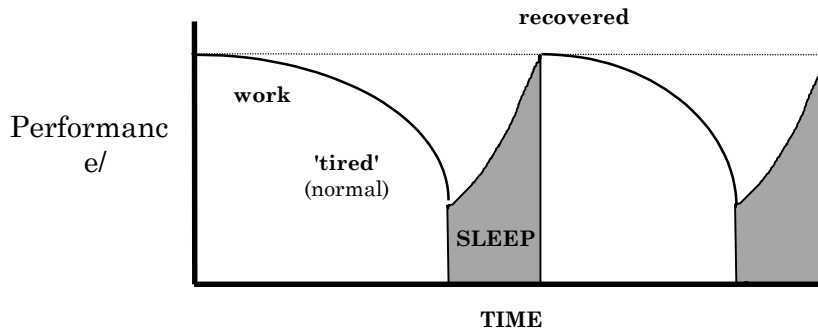
A lcohol or Drugs. Similar to driving; make sure you are not vulnerable to the side effects of alcohol or drugs. They are particularly bad news for our balance system and erode our judgement and decision making performance. Don’t fly with a hangover!

F atigue. Most of us will be well aware of our degraded personal performance when tired. Flying is a demanding exercise, both physically and mentally, so we must be well rested as sleeping on the job can be disastrous!

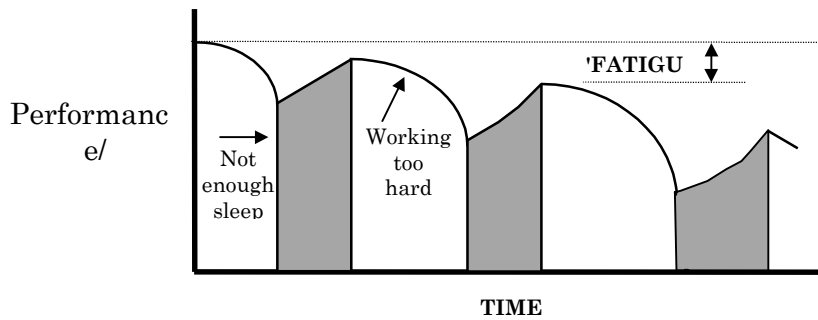
E ating. We are what we eat...eat well and we fly well; eat rubbish and we fly like rubbish! Ensure you have eaten well and take food along to have during the day. Don’t forget to take sufficient fluids to avoid dehydration. When flying, we process more water so the risk of dehydration with it’s detrimental effect on our performance is greater.

RECOVERY FROM FATIGUE

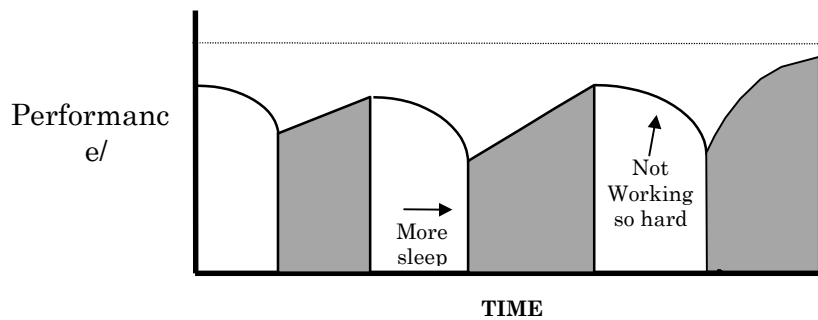
1. NORMAL PATTERN



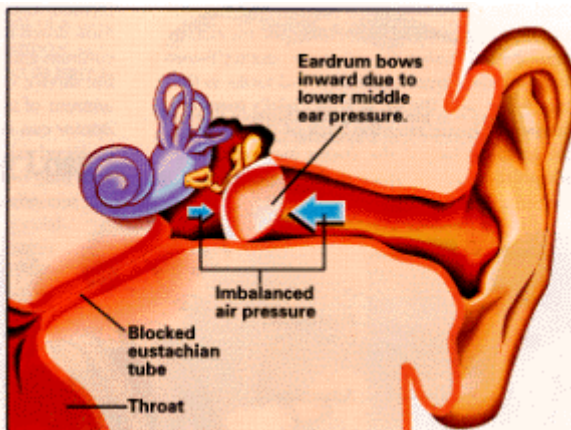
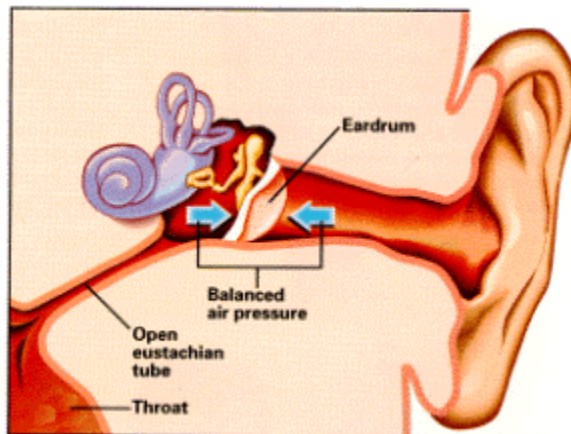
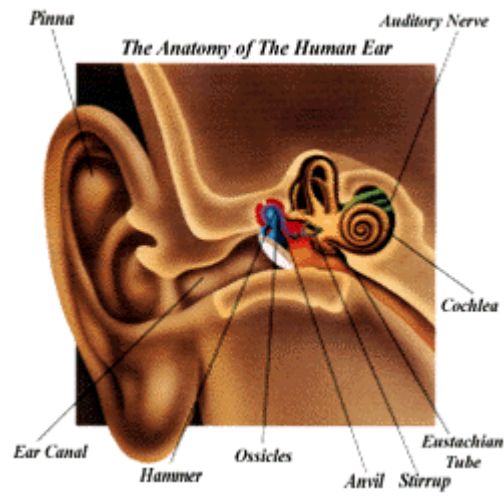
2. FATIGUE DEVELOPS



3. FATIGUE OVERCOME



PICTURES OF THE EAR



ALVEOLI

