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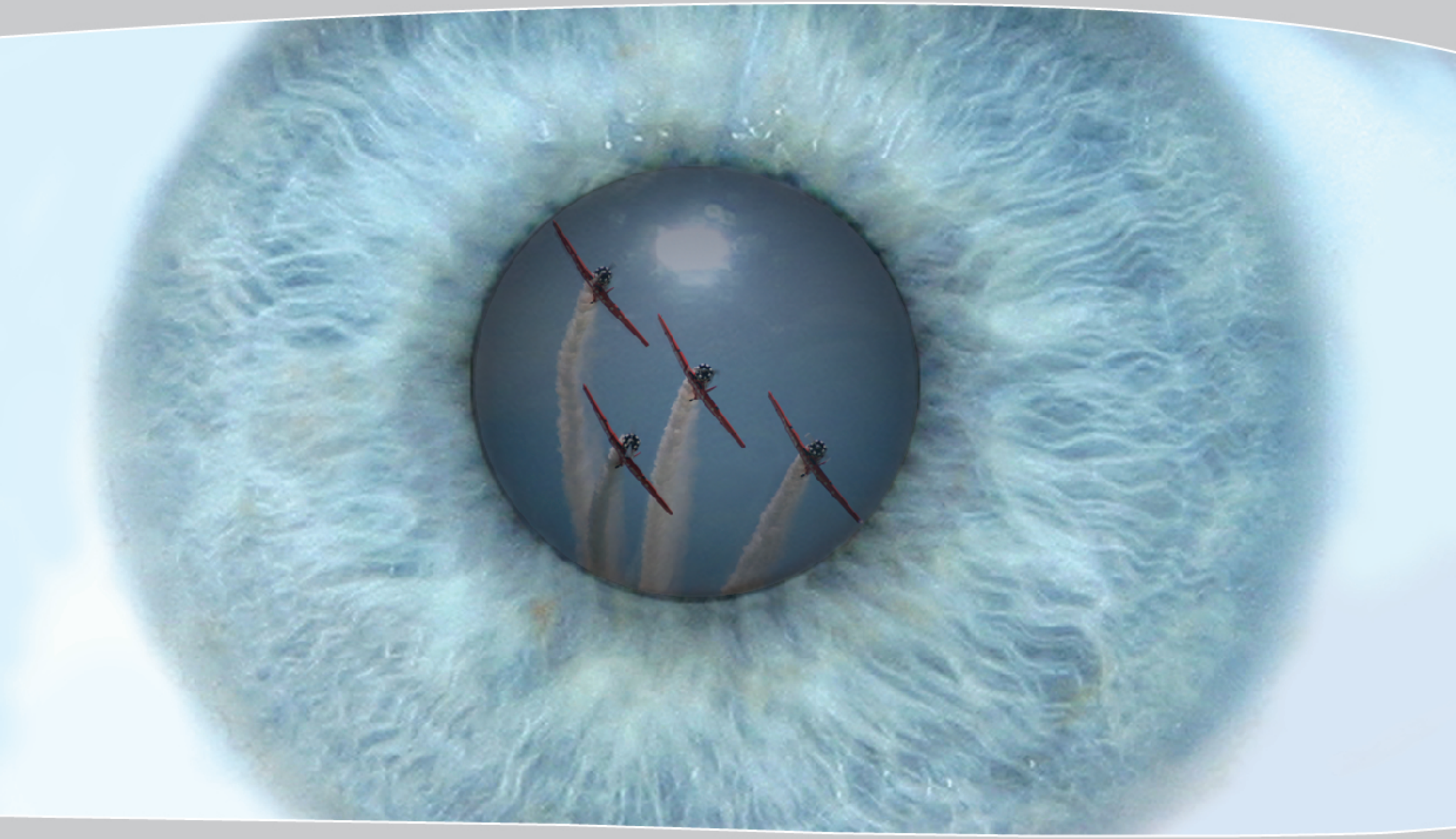

Complies with JAA/EASA PPL and UK NPPL syllabuses

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This text book has been written and published as a reference work for student pilots with the aims of helping them prepare for the PPL theoretical knowledge examinations, and to provide them with the aviation knowledge they require to become safe and competent pilots of light aeroplanes. The book is not a flying training manual and nothing in this book should be regarded as constituting practical flying instruction. In practical flying matters, students must always be guided by their instructor.

This book has been produced by CAE Oxford Aviation Academy.

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HUMAN PERFORMANCE

FOREWORD TO THE SECOND EDITION.

INTRODUCTION.

Whether you are planning to fly microlights, space shuttles, gliders, combat aircraft, airliners or light aircraft, it is essential that you have a firm grasp of the theoretical knowledge which underpins practical piloting skills. This Oxford Aviation Academy "Skills for Flight" series of text books covers the fundamental theory with which all pilots must come to grips from the very beginning of their pilot training, and which must remain with them throughout their flying career, if they are to be masters of the art and science of flight.

JOINT AVIATION AUTHORITIES PILOTS' LICENCES.

Joint Aviation Authorities (JAA) pilot licences were first introduced in Europe in 1999. By 2006, almost every JAA member state, including all the major countries of Europe, had adopted this new, pan-European licensing system at Air Transport Pilot's Licence, Commercial Pilot's Licence and Private Pilot's Licence levels, and many other countries, world-wide, had expressed interest in aligning their training with the JAA pilot training syllabi.

These syllabi, and the regulations governing the award and the renewal of licences, are defined by the JAA's licensing agency, 'Joint Aviation Requirements - Flight Crew Licensing', (JAR-FCL). JAR-FCL training syllabi are published in a document known as 'JAR-FCL 1.'

The United Kingdom Civil Aviation Authority (UK CAA) is one of the founder authorities within the JAA. The UK CAA has been administering examinations and skills tests for the issue of JAA licences since the year 2000, on behalf of JAR-FCL.

The Private Pilot's Licence (PPL), then, issued by the UK CAA, is a JAA licence which is accepted as proof of a pilot's qualifications throughout all JAA member states.

Currently, the JAA member states are: *United Kingdom, Denmark, Iceland, Switzerland, France, Sweden, Netherlands, Belgium, Romania, Spain, Finland, Ireland, Malta, Norway, Czech Republic, Slovenia, Germany, Portugal, Greece, Italy, Turkey, Croatia, Poland, Austria, Estonia, Lithuania, Cyprus, Hungary, Luxembourg, Monaco, Slovakia.*

As a licence which is also fully compliant with the licensing recommendations of the International Civil Aviation Organisation (ICAO), the JAA PPL is also valid in most other parts of the world.

The JAA PPL in the UK has replaced the full UK PPL, formerly issued solely under the authority of the UK CAA.

Issue of the JAA PPL is dependent on the student pilot having completed the requisite training and passed the appropriate theoretical knowledge and practical flying skills tests detailed in 'JAR-FCL 1'. In the UK, the CAA is responsible for ensuring that these requirements are met before any licence is issued.

EUROPEAN AVIATION SAFETY AGENCY.

With the establishment of the European Aviation Safety Agency (EASA), it is envisaged that JAA flight crew licensing and examining competency will be absorbed into the EASA organisation. It is possible that, when this change has taken place, the PPL may even change its title again, with the words "EASA" replacing "JAA". However, we do not yet know this for certain. In the UK, such a step would require the British Government to review and, where necessary, revise the Civil Aviation Act. But, whatever the future of the title of the PPL, the JAA pilot's licence syllabi are unlikely to change fundamentally, in the short term. So, for the moment, the JAA Licence remains, and any change in nomenclature is likely to be just that: a change in name only.

OXFORD AVIATION ACADEMY AND OAAMEDIA.

Oxford Aviation Academy (OAA) is one of the world's leading professional pilot schools. It has been in operation for over forty years and has trained more than 15 000 professional pilots for over 80 airlines, world-wide.

OAA was the first pilot school in the United Kingdom to be granted approval to train for the JAA ATPL. OAA led and coordinated the joint-European effort to produce the JAR-FCL ATPL Learning Objectives which are now published by the JAA, itself, as a guide to the theoretical knowledge requirements of ATPL training.

OAA's experience in European licensing, at all levels, and in the use of advanced training technologies, led OAA's training material production unit, OAAmedia, to conceive, create and produce multimedia, computer-based training for ATPL students preparing for JAA theoretical knowledge examinations by distance learning. Subsequently, OAAmedia extended its range of computer-based training CD-ROMs to cover PPL and post-PPL studies.

This present series of text books is designed to complement OAAmedia's successful PPL CD-ROMs in helping student pilots prepare for the theoretical knowledge examinations of the JAA PPL and beyond, as well as to provide students with the aviation knowledge they require to become safe and competent pilots.

The OAA expertise embodied in this series of books means that students working towards the JAA PPL have access to top-quality, up-to-date, study material at an affordable cost. Those students who aspire to becoming professional pilots will find that this series of PPL books takes them some way beyond PPL towards the knowledge required for professional pilot licences.

THE JAA PRIVATE PILOT'S LICENCE (AEROPLANES).

The following information on the Joint Aviation Authorities Private Pilot's Licence (Aeroplanes); (JAA PPL(A)) is for your guidance only. Full details of flying training, theoretical knowledge training and the corresponding tests and examinations are contained in the JAA document: **JAR–FCL 1, SUBPART C – PRIVATE PILOT LICENCE (Aeroplanes) – PPL(A).**

The privileges of the JAA PPL (A) allow you to fly as pilot-in-command, or co-pilot, of any aircraft for which an appropriate rating is held, but not for remuneration, or on revenue-earning flights.

For United Kingdom based students, full details of JAA PPL (A) training and examinations can be found in the CAA publication, **Licensing Administration Standards Operating Requirements Safety (LASORS),** copies of which can be accessed through the CAA's Flight Crew Licensing website.

Flying Training.

The JAA PPL (A) can be gained by completing a course of a minimum of 45 hours flying training with a training organisation registered with the appropriate National Aviation Authority (the Civil Aviation Authority, in the case of the United Kingdom).

Flying instruction must normally include:

- **25 hours** dual Instruction on aeroplanes.

- **10 hours** supervised solo flight time on aeroplanes, which must include **5 hours** solo cross-country flight time, including one cross-country flight of at least 150 nautical miles (270km), during which full-stop landings at two different aerodromes, different from the aerodrome of departure, are to be made.

The required flying-instructional time may be reduced by a maximum of 10 hours for those students with appropriate flying experience on other types of aircraft.

The flying test (Skills Test), comprising navigation and general skills tests, is to be taken within 6 months of completing flying instruction. All sections of the Skills Test must be taken within a period of 6 months. A successfully completed Skills Test has a period of validity of 12 months for the purposes of licence issue.

Theoretical Knowledge Examinations.

The procedures for the conduct of the JAA PPL (A) theoretical knowledge examinations will be determined by the National Aviation Authority of the state concerned, (the Civil Aviation Authority, in the case of the United Kingdom).

The JAA theoretical knowledge examination must comprise the following 9 subjects: *Air Law, Aircraft General Knowledge, Flight Performance and Planning, Human Performance and Limitations, Meteorology, Navigation, Operational Procedures, Principles of Flight, Communication.*

A single examination paper may cover several subjects.

The combination of subjects and the examination paper titles, as administered by the UK CAA, are, at present:

1. Air Law and Operational Procedures.
2. Human Performance and Limitations.
3. Navigation & Radio Aids.
4. Meteorology.
5. Aircraft (General) & Principles of Flight.
6. Flight Performance and Planning.
7. JAR-FCL Communications (PPL) (i.e. Radiotelephony Communications).

The majority of the questions are multiple choice. In the United Kingdom, examinations are normally conducted by the Flying Training Organisation or Registered Facility at which a student pilot carries out his training.

The pass mark in all subjects is 75%.

For the purpose of the issue of a JAA PPL(A), a pass in the theoretical knowledge examinations will be accepted during the 24 month period immediately following the date of successfully completing all of the theoretical knowledge examinations.

Medical Requirements.

An applicant for a JAR-FCL PPL(A) must hold a valid JAR-FCL Class 1 or Class 2 Medical Certificate.

THE UNITED KINGDOM NATIONAL PRIVATE PILOT'S LICENCE (AEROPLANES).

One of the aims of the United Kingdom National Private Pilot's Licence (UK NPPL) is to make it easier for the recreational flyer to obtain a PPL than it would be if the requirements of the standard JAA-PPL had to be met. The regulations governing medical fitness are also different between the UK NPPL and the JAA PPL.

Full details of the regulations governing the training for, issue of, and privileges of the UK NPPL may be found by consulting LASORS and the Air Navigation Order. Most UK flying club websites also give details of this licence.

Basically, the holder of a UK NPPL is restricted to flight in a simple, UK-registered, single piston-engine aeroplane (including motor gliders and microlights) whose Maximum Authorized Take-off Weight does not exceed 2000 kg. Flight is normally permitted in UK airspace only, by day, and in accordance with the Visual Flight Rules.

Flying Training.

Currently, 32 hours of flying training is required for the issue of a UK NPPL (A), of which 22 hours are to be dual instruction, and 10 hours to be supervised solo flying time.

There are separate general and navigation skills tests.

Theoretical Knowledge Examinations.

The UK NPPL theoretical knowledge syllabus and ground examinations are the same as for the JAA PPL (A). This series of books, therefore, is also suitable for student pilots preparing for the UK NPPL.

THE UNITED KINGDOM FLIGHT RADIOTELEPHONY OPERATOR'S LICENCE.

Although there is a written paper on Radiotelephony Communications in the JAA PPL theoretical knowledge examinations, pilots in the United Kingdom, and in most other countries, who wish to operate airborne radio equipment will need to take a separate practical test for the award of a Flight Radiotelephony Operators Licence (FRTOL). For United Kingdom based students, full details of the FRTOL are contained in LASORS.

NOTES ON CONTENT AND TEXT.

Technical Content.

The technical content of this OAA series of pilot training text books aims to reach the standard required by the theoretical knowledge syllabus of the JAA Private Pilot's Licence (Aeroplanes), (JAA PPL(A)). This is the minimum standard that has been aimed at. The subject content of several of the volumes in the series exceeds PPL standard. However, all questions and their answers, as well as the margin notes, are aimed specifically at the JAA PPL (A) ground examinations.

An indication of the technical level covered by each text book is given on the rear cover and in individual subject prefaces. The books deal predominantly with single piston-engine aeroplane operations.

Questions and Answers.

Questions appear at the end of each chapter in order that readers may test themselves on the individual subtopics of the main subject(s) covered by each book. The questions are of the same format as the questions asked in the JAA PPL (A) theoretical knowledge examinations, as administered by the UK CAA. All questions are multiple-choice, containing four answer options, one of which is the correct answer, with the remaining three options being incorrect "distracters".

Students Working for a Non-JAA PPL.

JAA licence training syllabi follow the basic structure of ICAO-recommended training, so even if the national PPL you are working towards is not issued by a JAA member state, this series of text books should provide virtually all the training material you need. Theoretical knowledge examinations for the JAA PPL are, however, administered nationally, so there will always be country-specific aspects to JAA PPL examinations. 'Air Law' is the most obvious subject where country-specific content is likely to remain; the other subject is 'Navigation', where charts will most probably depict the terrain of the country concerned.

As mentioned elsewhere in this Foreword, this series of books is also suitable for student pilots preparing for the United Kingdom National Private Pilot's Licence (UK NPPL). The theoretical examination syllabus and examinations for the UK NPPL are currently identical to those for the JAA PPL.

Student Helicopter Pilots.

Of the seven book in this series, the following are suitable for student helicopters pilots working towards the JAA PPL (H), the UK NPPL (H) or the equivalent national licence:

Volume 1: 'Air Law & Operational Procedures'; Volume 2: 'Human Performance'; Volume 3: 'Navigation & Radio Aids'; Volume 4: 'Meteorology', and Volume 7: 'Radiotelephony'.

The OAAmedia Website.

If any errors of content are identified in these books, or if there are any JAA PPL (A) theoretical knowledge syllabus changes, Oxford Aviation Academy's aim is to record those changes on the product support pages of the OAAmedia website, at: www.oaamedia.com

Grammatical Note.

It is standard grammatical convention in the English language, as well as in most other languages of Indo-European origin, that a single person of unspecified gender should be referred to by the appropriate form of the masculine singular pronoun, *he*, *him*, or *his*. This convention has been used throughout this series of books in order to avoid the pitfalls of usage that have crept into some modern works which contain frequent and distracting repetitions of *he or she*, *him or her*, *etc*, or where the ungrammatical use of *they*, and related pronouns, is resorted to. In accordance with the teachings of English grammar, the use, in this series of books, of a masculine pronoun to refer to a single person of unspecified gender does not imply that the person is of the male sex.

Margin Notes.

You will notice that margin notes appear on some pages in these books, identified by one of two icons:

a key or a set of wings .

The key icon identifies a note which the authors judge to be a key point in the understanding of a subject; the wings identify what the authors judge to be a point of airmanship.

The UK Theoretical Knowledge Examination Papers.

The UK CAA sets examination papers to test JAA PPL (A) theoretical knowledge either as single-subject papers or as papers in which two subjects are combined.

Two examination papers currently cover two subjects each:

- **Aircraft (General) & Principles of Flight**: The 'Aircraft (General) & Principles of Flight' examination paper, as its title suggests, covers 'Principles of Flight' and those subjects which deal with the aeroplane as a machine, 'Airframes', 'Engines', 'Propellers' and 'Instrumentation', which JAR-FCL groups under the title 'Aircraft General Knowledge'.

- **Flight Performance & Planning:** The examination paper entitled 'Flight Performance & Planning' covers both 'Aeroplane Performance, and 'Mass & Balance'.

When preparing for the two examinations named above, using this Oxford series of text books, you will need **Volume 5, 'Principles of Flight'**, which includes 'Aeroplane Performance', and **Volume 6, 'Aeroplanes'**, which includes 'Mass & Balance' as well as 'Airframes', 'Engines', 'Propellers', and 'Instrumentation'. So to prepare for the 'Aircraft (General) & Principles of Flight' examination, you need to take the **'Aeroplanes'** infomation from **Volume 6** and the **'Principles of Flight'** information from **Volume 5**. When you are preparing for the 'Flight Performance & Planning' examination you need to take the **'Aeroplane Performance'** information from **Volume 5** and the **'Mass & Balance'** information from **Volume 6**.

It has been necessary to arrange the books in this way for reasons of space and subject logic. The titles of the rest of the volumes in the series correspond with the titles of the examinations. The situation is summed up for you in the table on the following page:

JAA Theoretical Examination Papers	Corresponding Oxford Book Title
Air Law and Operational Procedures	Volume 1: Air Law
Human Performance and Limitations	Volume 2: Human Performance
Navigation and Radio Aids	Volume 3: Navigation
Meteorology	Volume 4: Meteorology
Aircraft (General) and Principles of Flight	Volume 5: Principles of Flight Volume 6: Aeroplanes
Flight Performance and Planning	Volume 5: Aeroplane Performance Volume 6: Mass and Balance
JAR-FCL Communications (PPL)	Volume 7: Radiotelephony

Regulatory Changes.

Finally, so that you may stay abreast of any changes in the flying and ground training requirements pertaining to pilot licences which may be introduced by your national aviation authority, be sure to consult, from time to time, the relevant publications issued by the authority. In the United Kingdom, the Civil Aviation Publication, LASORS, is worth looking at regularly. It is currently accessible, on-line, on the CAA website at **www.caa.co.uk**.

Oxford,
England

August 2011

TO THE PILOT.

For a pilot, the study of Human Performance is crucial to an understanding of the central role played by the human factor in promoting safety and efficiency in flying operations.

In flight, the environment in which the pilot operates can be quite different to that which prevails on the ground. When in the air, alongside the tasks of flying the aircraft, maybe in marginal weather conditions, or in a busy air traffic and radiotelephony environment, the pilot is subject to new influences, unknown on the ground, such as altitude, changes in pressure, possible oxygen shortage, increased “g” forces, etc. As a pilot, a thorough understanding of Human Performance, and of the limitations to that performance, is essential if you are to develop the high standards of airmanship required of all those who fly, whether privately or professionally.

Amongst other things, this book attempts to examine the demands of the flying environment on the human organism and to illustrate to you the obligation on all pilots to keep fit and to lead a healthy life style if they are to operate efficiently and safely in the air. The book also covers the basic psychological considerations of piloting, such as the demands that flying places on a pilot’s faculties of perception, communication, judgment and decision making, and by pointing out some important limitations of those faculties.

Above all, the study of Human Performance is about furthering the cause of flight safety.

In the very early days of aviation, very many aircraft accidents were caused by equipment failure or by other factors beyond the control of the pilot. But since the Second World War, it has been human error or human failing that has caused the majority of accidents. Human error is most often attributable to pilots, themselves, but also to maintenance personnel and air traffic controllers.

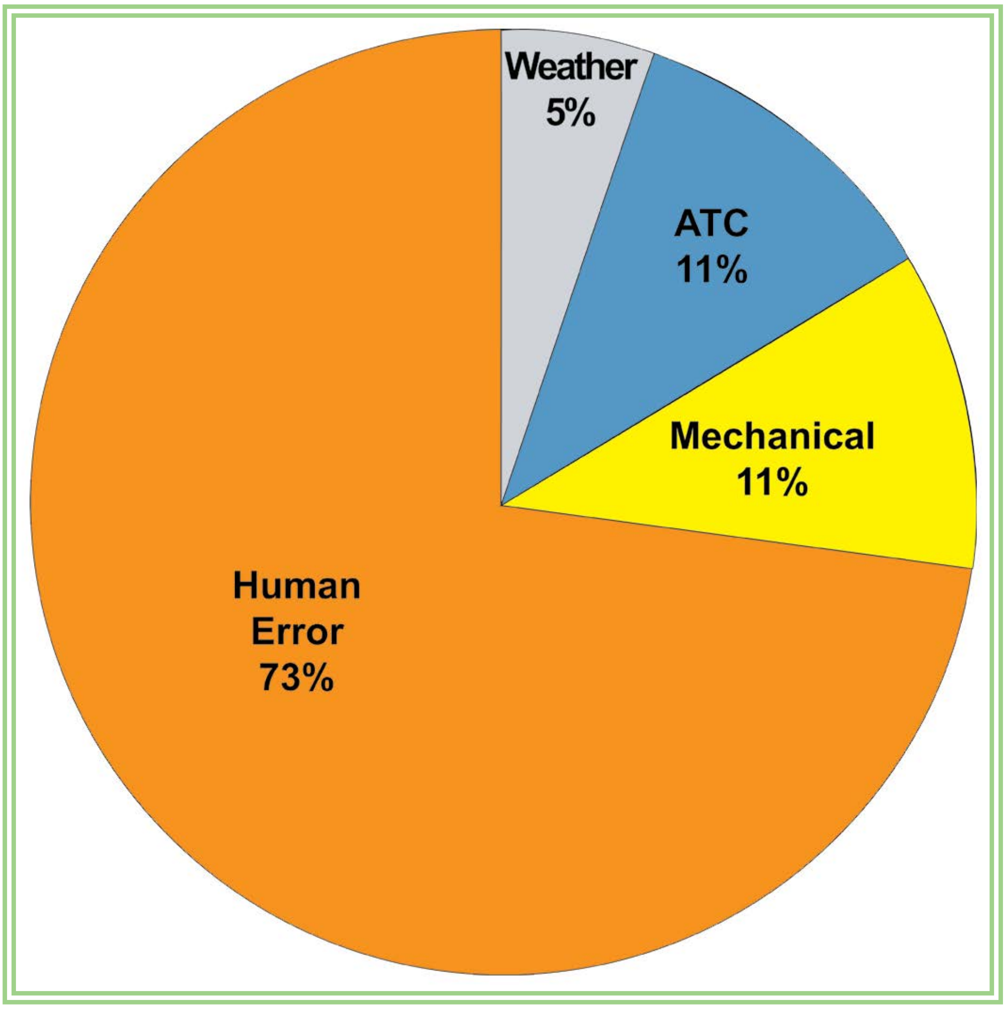
The principal aim of this book, then, is that you should learn the essentials about the interaction between the human being, the aircraft and the flying environment. It is hoped that, after working through this volume, you will appreciate the human body’s limitations when operating in an aviation environment and that, in understanding those limitations, you will never, yourself, become a human factor in any aircraft accident.

An important secondary aim of the book is that it should assist you in the task of preparing yourself for success in the PPL theoretical knowledge examination in ‘Human Performance and Limitations’.

To this end, the content of this volume is fully compliant with the EASA PPL (A) theoretical knowledge syllabus.

CHAPTER 1

INTRODUCTION



TYPICAL CAUSES OF AIRCRAFT ACCIDENTS AT THE BEGINNING OF THE 21ST CENTURY

Customer: Oleg Ostapenko E-mail: ostapenko2002@yahoo.com

CHAPTER 1: INTRODUCTION

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INTRODUCTION.

As you read this introductory chapter on ‘Human Performance and Limitations’, you may find it of interest to reflect on the following two quotations from days gone by.

“There’s nothing new under the sun, but there are lots of old things we don’t know.”
Ambrose Bierce 1842 – 1914

“Seventy-five percent of all accidents happen when taxying, taking off or landing. These are not difficult things for the experienced pilot to do; the accidents happen when he allows attention and accuracy of performance to lapse.”
From ‘Cadets’ Handbook of Elementary Flying Training’ issued by the Air Ministry April 1943

In the very early days of aviation, many aircraft accidents were caused by equipment failure or other factors beyond the control of the pilot. But in the past fifty years or so, human error or failing has been the major cause of accidents, most often attributable to flight crew but also to maintenance personnel and air traffic controllers.

So today, the main cause of aircraft accidents is Pilot Error or Human Failing.

Airframes have become more reliable, modern engines and associated equipment seldom fail, and navigational equipment (both in the aircraft and on the ground) has improved in leaps and bounds, giving a degree of accuracy undreamt of by the early pioneers of flying. This improvement in the equipment available, allied with the advances in meteorological forecasting should have virtually eliminated aviation accidents except in the most freak conditions, but aircraft accidents have not reduced at the rate one would expect given the advances of technology.

The accident factor that has not changed with advancing technology is, of course, human fallibility.

It is often seen in reports of aircraft accidents that the cause was ‘Pilot Error’: a more correct reason would be ‘Human Error’.

Human Error can occur at all stages of an aircraft’s life or operation.

Designers may make small arithmetical slips which may not be picked up. Servicing personnel can put the wrong fuel and lubricants into fuel tanks and engines, or fit components incorrectly. Operations and loading staff can also get the weights wrong.

The major cause of accidents, however, is pilot error. Consequently, this book on Human Performance and Limitations has been designed to help you, the pilot, to appreciate the limitations of the human being operating in an aviation environment.

When flying, the human body is exposed to an environment and to forces not usually experienced in normal daily activities on the Earth’s surface. Pilots must learn, therefore, to recognise the physiological effects that flying an aircraft can have on their body.

Human beings are designed to exist on the surface of the earth, in the lower atmosphere, and to be subject to an unchanging gravitational force. But, when flying,

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the human body is exposed to a new environment such as the rarefied air and low pressures associated with higher altitudes and variations in gravitational force often referred to as “g”.

It is true that most private pilots flying light aircraft, in Europe, operate at altitudes below 10 000 feet. But your licence may entitle you to fly aircraft with much higher operating ceilings. As a pilot, therefore, you will need to learn, amongst other things, how to recognise the symptoms of oxygen deficiency and the effects of high “g” forces or significant changes in temperature.

You will also need to develop an appreciation of the psychological aspects of flying such as perceiving and processing information under high work loads, assessing data, making decisions and carrying out the necessary actions to ensure the safe progress of your flight in all conditions.

By following this book conscientiously, you will learn some of the ways in which mistakes occur and how to reduce your potential for error-making to a minimum.

We, of course, hope that you will not have to face any real emergencies in your flying career, but to be forewarned is to be forearmed. Knowledge brings confidence. This book is designed to increase your knowledge of yourself and of your limitations, and, thereby, greatly increase your chances of enjoying an accident-free flying career.

Men and woman have been piloting powered aircraft for about 100 years, so there are a lot of teachers to learn from. Much of the old advice is still good, especially where light aircraft flying is concerned. The manual of elementary flying training issued to Second World War aircrew cadets by the Air Ministry emphasised to pupil pilots:

“Watch your own progress, and practise the things you do badly. After a flight, go over it in your mind and extract from it the new lessons it most certainly has to teach you.” Some things never change!

Aviation, in itself, is not inherently dangerous but, like the sea, it is inordinately unforgiving of any carelessness, incapacity or neglect. Human Performance and Limitations considerations are relevant wherever and whenever the human being is involved in aviation. Thus, the subject plays a fundamental and vital role in promoting the efficiency and expediency of flight operations. But, above all else, knowledge of Human Performance and Limitations promotes the cause of flight safety.

The subject of Human Performance and Limitations (sometimes referred to as Human Factors) plays a vital role in improving efficiency and, above all else, safety in every facet of the aviation industry, promoting:

- Safety and efficiency of flight operations.
- Health, fitness and well-being.
- Operating skills.
- Awareness of the common areas of human error.
- Judgement and decision-making.

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- Leadership qualities.
- Crew co-ordination.
- Use of check lists and charts.
- Getting maximum benefit from training.
- Good communications.

THE COMPETENT PILOT.

Another principal aim of Human Performance and Limitations is to endow you with an outlook and approach to flying matters which, at the same time as achieving the aims already stated, will make you into a competent pilot.

The competent pilot conducts himself in such a way that the flying operations in which he is involved take place safely and expeditiously and achieve the aim of the sortie.

Qualities of a Competent Pilot.

A competent pilot:

- Possesses a high sense of responsibility.
- Has high ability (academic and piloting/aircraft handling skills).
- Is well motivated.
- Is a good communicator.
- Is flexible.
- Is physically fit.
- Is reliable.
- Has a balanced personality.
- Is a team player.
- Remains calm under stress.
- Has an eye for detail.
- Is competent in Risk Assessment.
- Is competent in the skills of Stress and Crew Management.

Note well the qualities of a competent pilot.

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Self-Training.

During your formal flying training, your flying will be carried out under the supervision or authorisation of your flying instructor. Your flying instructor will structure the training and deliver practical and theoretical instruction. He will give you briefings before training sorties, and, after the sortie, he will carry out a de-brief.

The training process should, however, never cease. That is where self-training comes in. Self-training is a process aimed at developing within yourself specific skills, knowledge and attitudes.

Talk to others about aspects of piloting and aviation that concern or interest you. It is of fundamental importance that you do not rely solely on formal training to maintain or further your aviation expertise.

Every opportunity should be taken to increase your competency, knowledge and professionalism.

Set yourself an aim for every flight and always self de-brief after landing.

As your competence and expertise increase so will your self-confidence. This, in turn, will enable you to tackle new aspects of flying with enthusiasm and conviction.

AIRCRAFT ACCIDENT STATISTICS.

Human error is the single greatest cause of aircraft accidents. When compared with other forms of transport, aviation has the best safety record. The risk of death per person per year in a car accident is 1 in 10 000 in the UK (0.01 % probability) and 1 in 4 000 (0.025% probability) in the USA. The flying accident rate is approximately 1 per million airport movements - in other words, approximately one accident per million legs flown.

73% of all accidents are caused by Human Error.

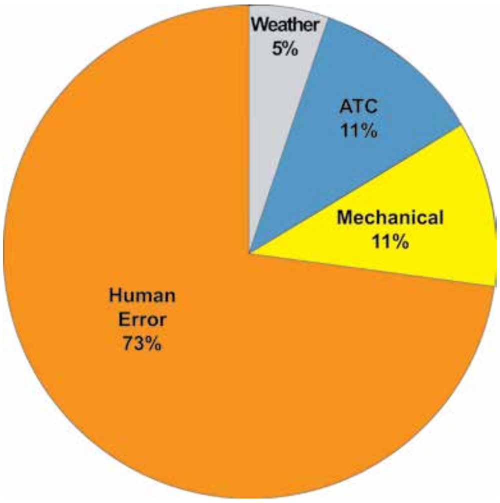


Figure 1.1 Causes of Aircraft Accidents.

Despite the many technical advances in aircraft and engine design, instrumentation and air traffic control, and improvements in overall standards of safety that have been achieved in recent decades, the complex relationship between man, the flying machine and the air in which both fly still causes accidents to happen. As you can see from *Figure 1.1,* the fallibility of the human being is the single greatest cause of flying accidents.

In aviation, perhaps more than in other fields of human endeavour, mankind remains as much a victim of himself as of the elements around him.

And, of all the accidents due to human error, controlled flight into terrain is the most common form of air accident.

*Figure 1.2 Controlled Flight into Terrain is the most common form of Air Accident.
Picture of SP-ANA by kind permission of Jedrzej Wiler.*

Causes of Accidents - Pilot Induced.

The five most common specific causes of pilot-induced accidents, in order of frequency of occurrence, are:

- Loss of directional control.
- Poor judgement.
- Airspeed not maintained.
- Poor pre-flight planning and pre-flight decision making.
- Not maintaining ground clearance.

The phases of flight most prone to accidents, starting with the most common are:

- Intermediate and Final Approach.
- Landing.
- Take-off.
- Descent.

RESPONSIBILITY OF THE PILOT IN COMMAND.

In VFR flying it is the Pilot In Command who is responsible for the safety of his aircraft and passengers. He can fulfil this responsibility only if he is aware of the many different facets of human factors and limitations in the conduct of safe and expeditious aircraft operations.

As to be aware of and to recognise one's responsibilities is to be halfway towards carrying them out, we will end this introduction to Human Performance and Limitations by mentioning some of the most important responsibilities of the Pilot In Command. The responsibilities we mention are not exhaustive. Your flying instructor will give you further guidance. The following is a list of the pilot's principal responsibilities:

- Be responsible for the safe operation of the aircraft and the safety of its occupants and cargo. This responsibility begins when the pilot first signs for the aircraft and does not cease until he signs the after-flight declaration.
- Ensure that all passengers are briefed on the emergency exit procedures and the use of relevant safety and emergency equipment.
- Maintain familiarity with relevant air legislation, practices and procedures.
- Ensure that all operational procedures and checklists are complied with.
- Ensure that the aircraft and any required equipment are serviceable.
- Ensure that aircraft refuelling is supervised, paying particular attention to:
  - (i) The correct grade and amount of fuel, as well as fuel water checks.
  - (ii) Fire safety precautions.
  - (iii) Checking filler caps are correctly replaced after refuelling.
- Ensure that the aircraft mass and balance is within the calculated limits for the operating conditions.
- Confirm that the aircraft's performance will enable it to safely complete the proposed flights.
- Ensure that all passengers are properly secured in their seats, and all baggage is stowed safely.
- Ensure that the required documents and manuals are carried and will remain valid throughout the flight or series of flights.
- Ensure that the pre-flight inspection has been carried out.
- Ensure that a continuous listening watch is maintained on the appropriate radio frequencies at all times.
- Ensure the welfare of passengers.

Representative PPL - type questions to test your theoretical knowledge.

1. Who is responsible for the safety of an aircraft flying in accordance with the Visual Flight Rules?

   a. The occupants of the cockpit
   b. The Pilot-In-Command of the aircraft
   c. Everyone
   d. Your flying instructor

2. One essential quality that a competent pilot should possess is:

   a. Poor communication skills
   b. An impulsive personality
   c. The ability to predict weather changes
   d. A highly developed sense of responsibility

3. The percentage of all accidents caused by human factors is:

   a. 70% - 75%
   b. 60% - 65%
   c. 50% - 55%
   d. 80% - 90%

4. The most common form of aircraft accident is:

   a. Failing to file a flight plan
   b. Controlled flight into terrain
   c. Failure to maintain the correct airspeed
   d. Mid-air collision

5. The most common cause of pilot-induced accidents is:

   a. Poor flight planning
   b. Mid-air collision
   c. Loss of control whilst taxiing
   d. Loss of directional control

6. The phase of flight most prone to accident is:

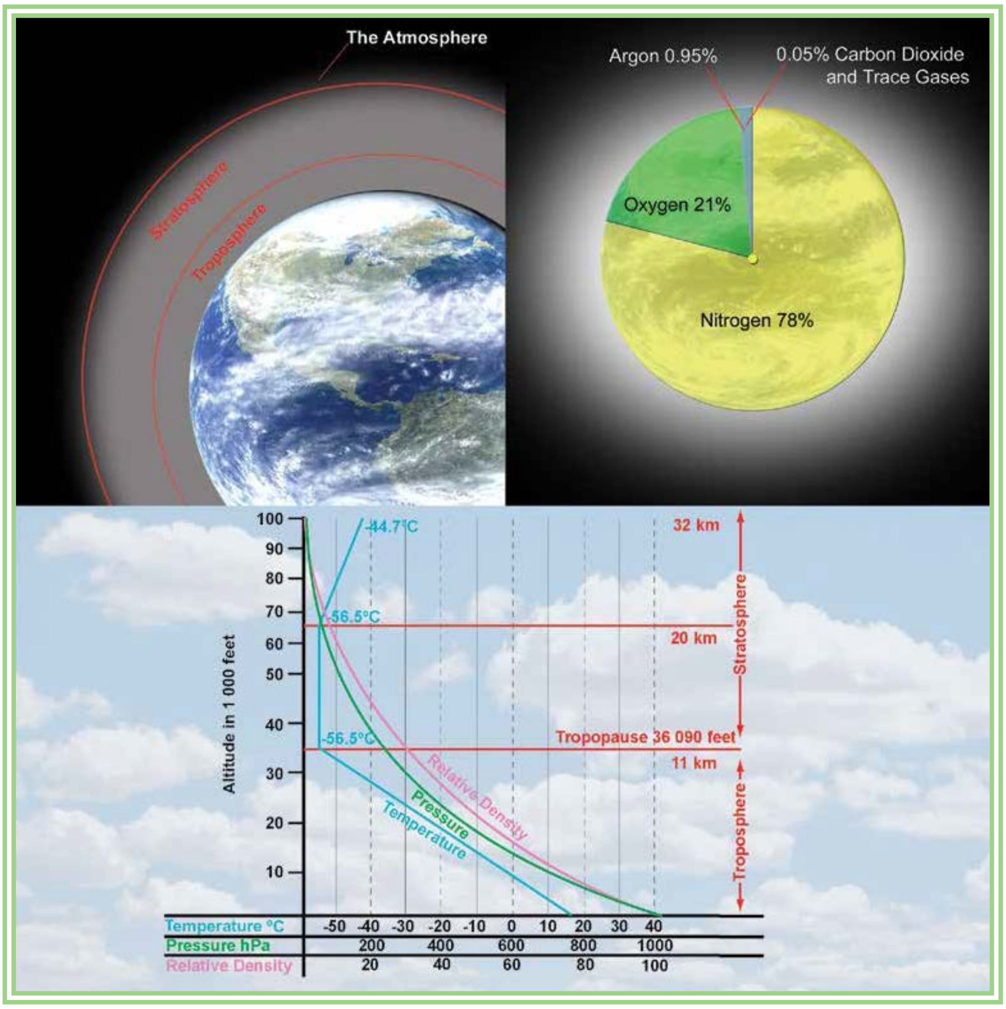
   a. Intermediate and final approach
   b. Cruise
   c. Descent
   d. Take-off

Question	**1**	**2**	**3**	**4**	**5**	**6**
Answer						

The answers to these questions can be found at the end of this book.

CHAPTER 2

THE ATMOSPHERE



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INTRODUCTION.

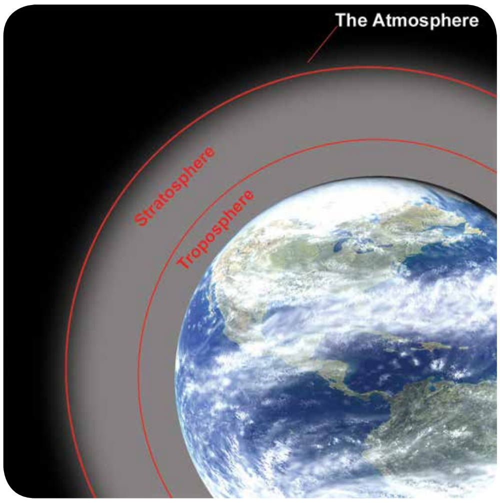

Figure 2.1 The Troposphere and the Stratosphere.

The Earth's atmosphere is the envelope of air which surrounds our planet.

In Human Performance and Limitations, knowledge of the atmosphere is especially important to pilots if they are to operate safely at altitude.

All aeroplane flights take place within the atmosphere, because aircraft, by definition, rely on air to generate the lift which keeps them airborne. Aircraft engines, too, unless they are rockets, rely on air for the combustion process which is essential to their function.

Human beings live their lives in the lower reaches of the atmosphere where temperatures, pressures and Oxygen supply are able to support life.

The two layers of the atmosphere in which all conventional aeroplane flights take place are the Troposphere, closest to the Earth, and the layer above it, the Stratosphere. For our purposes in Human Performance and Limitations, the Troposphere may be considered to stretch from the Earth's surface to an altitude of about 11 km (36 000 feet). The Stratosphere reaches from 11 km to over 32 km (100 000 feet), but all light aircraft flying takes place in the Troposphere.

The Troposphere contains three quarters of the total atmosphere, measured by weight of air, and also contains almost all weather.

MAIN CONSTITUENT GASES OF THE ATMOSPHERE (BY VOLUME).

The principal gases in the Earth's atmosphere are in the following proportions, by volume:

- Nitrogen 78%.
- Oxygen almost 21%.
- The remaining 1% of the air consists of 0.95% Argon plus 0.05% Carbon Dioxide and traces of other gases.

The relative proportions of these gases remain constant throughout the Troposphere and Stratosphere.

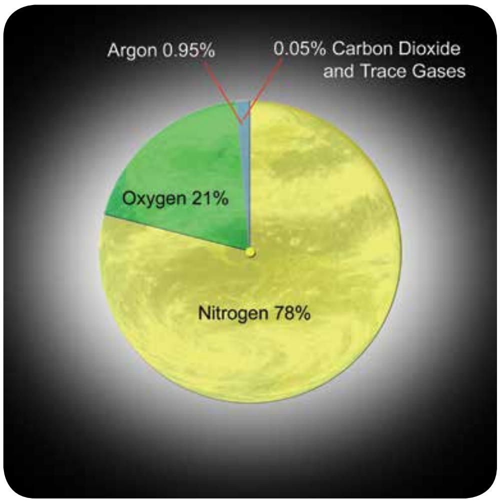

Figure 2.2 Constituent Gases of the Atmosphere.

The atmosphere is composed of:

78% Nitrogen

21% Oxygen

1% Other gases

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THE VARIATION OF PRESSURE AND TEMPERATURE WITH ALTITUDE.

ISA gives standardised values for temperature, pressure, density, etc, in a “standard” atmosphere.

The International Civil Aviation Organisation (ICAO) Standard Atmosphere (ISA) gives standardised values for temperature, pressure, density etc.

As you are aware, real atmospheric conditions, (pressure, temperature, humidity, etc) change from day to day. So, in order to have a “standard atmosphere” which they can use to describe general atmospheric conditions, scientists have created the ISA.

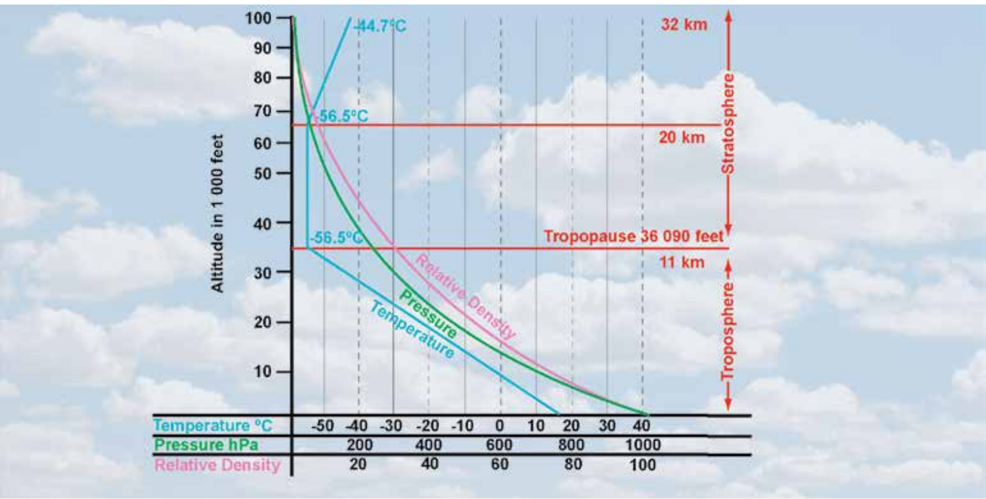

Figure 2.3 The ICAO Standard Atmosphere (ISA).

ISA conditions may never be present on any given day, but they give us a yardstick by which to measure atmospheric phenomena.

In the ISA, sea-level pressure is 1013.25 Hectopascals (760 mm of Mercury (Hg)), and temperature is 15º Celsius.

Temperature reduces with height at 0.65º Celsius per 100 m (1.98ºC per 1000 feet). This is known as the Environmental Lapse Rate, of which you will learn more in Meteorology.

A closer look at *Figure 2.3* will reveal that while pressure and density reduce with increasing altitude throughout the atmosphere as a whole, temperature falls with increasing altitude throughout the Troposphere only, while, in the Stratosphere, temperature remains constant at -56.5º Celsius up to 20 km, and then increases at 0.1ºC/100 m to 32 km.

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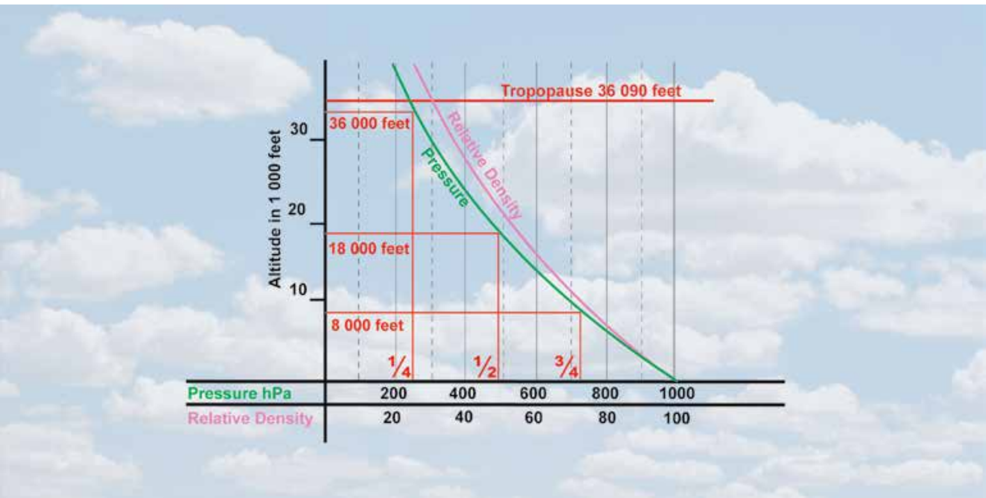

Figure 2.4 Pressure and Density against Height in the ICAO Standard Atmosphere.

Many of the details on the ISA graph do not concern us in Human Performance and Limitations, but you should note the rate at which pressure and density reduce with increasing altitude. The fact that air pressure and air density decrease as altitude increases is the reason why human beings need a supply of supplementary Oxygen above an altitude of 10 000 to 12 000 feet.

The partial pressure of Oxygen decreases with increased altitude, which is why a pilot will need supplementary Oxygen above 10 000 feet.

Pressure decreases with altitude at the following rate.

At 8 000 feet the pressure is ¾ of its sea-level value.

At 18 000 feet the pressure is ½ that at sea-level.

By 36 000 feet the pressure has reduced to only ¼ of its sea-level value.

THE PARTIAL PRESSURE OF OXYGEN.

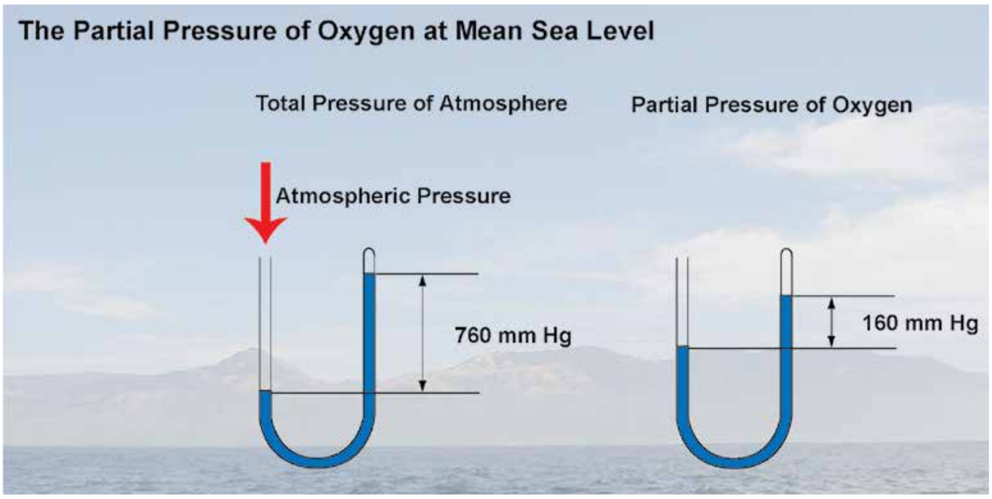

Figure 2.5 The Partial Pressure of Oxygen.

The percentage of Oxygen in the atmosphere remains constant up to about 70 000 feet, making up 21% by volume of the air we breathe.

Despite the reduction of atmospheric (air) pressure with increasing altitude, Oxygen continues to make up 21% by volume of the air we breathe, whatever the altitude or pressure (up to 70 000 feet).

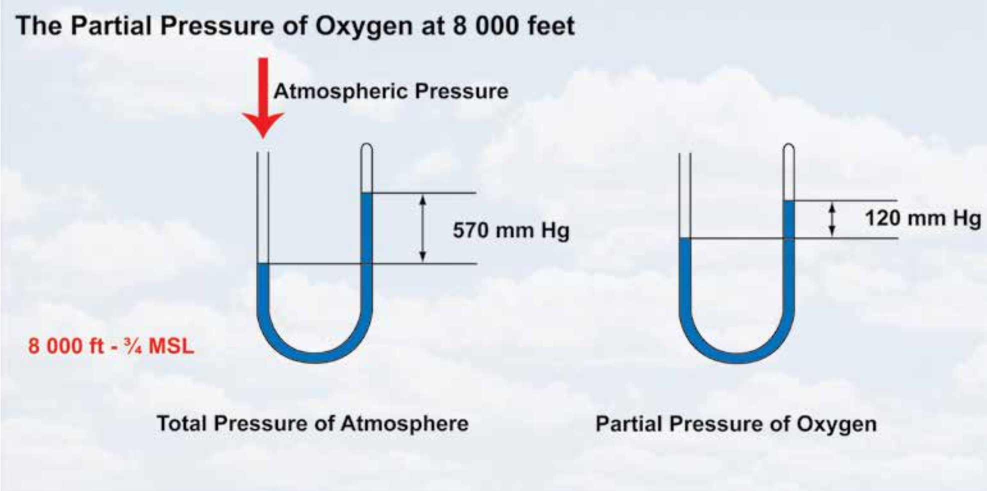

Figure 2.6 The Partial Pressure of Oxygen at 8000 feet above mean sea level.

In order that we may understand how our breathing is affected by increasing altitude, it is important to note that as the air pressure overall decreases with altitude, the partial pressure of Oxygen also decreases with altitude at the same rate. Partial pressure refers to pressure exerted by any one of the constituent gases making up the atmosphere. Thus, Oxygen which constitutes 21% of the atmosphere exerts 21% of the total pressure.

For example, we know that ISA sea-level pressure is 1013.25 Hectopascals. This is equivalent to 760 millimetres of Mercury (Hg) because air pressure can support a column of Mercury 760 millimetres in height at sea-level. Oxygen, making up 21% of the air by volume, consequently has a partial pressure of 160 millimetres of Mercury at sea-level (21% × 760 = 160).

At 8 000 ft, total air pressure, measured in mm of Mercury, is only 570 mm. The partial pressure of Oxygen at 8 000 feet is, therefore, 120 mm of Mercury. (21% × 570 = 120).

So the partial pressure of Oxygen decreases with altitude along with the total pressure of the air.

It is this reduction in the partial pressure of Oxygen with increasing altitude which explains why a pilot needs to breathe supplementary Oxygen when flying higher than a given altitude.

However, a healthy pilot will be able to operate for considerable periods without suffering the effects of Oxygen deprivation (hypoxia) up to and including an altitude of 10 000 feet.

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Representative PPL - type questions to test your theoretical knowledge of The Atmosphere.

1. The percentage of Oxygen in the atmosphere:

    a. Decreases with an increase in altitude
    b. Remains constant up to approximately 33 700 feet
    c. Remains constant up to approximately 70 000 feet
    d. Increases with an increase in altitude

2. The approximate altitude where the atmospheric pressure is half the sea-level value is:

    a. 10 000 feet
    b. 12 000 feet
    c. 18 000 feet
    d. 33 000 feet

3. A healthy pilot should be able to operate without suffering the effects of hypoxia up to altitudes of:

    a. 10 000 feet
    b. 16 000 feet
    c. 18 000 feet
    d. 20 000 feet

4. The percentage of Oxygen in the atmosphere remains at 21%, by volume:

    a. Up to 10 000 feet
    b. Up to 18 000 feet
    c. Up to 8 000 feet
    d. Throughout the majority of the atmosphere

5. Pilots need to breathe supplementary Oxygen when flying at high altitude because of:

    a. The decreased temperature
    b. Decreased atmospheric pressure, and a decrease in the partial pressure of Oxygen
    c. A decrease in the proportion of Oxygen by volume
    d. The upper limit of the Troposphere

6. The respective percentages of the gases that make up the atmosphere are:

    a. Nitrogen 78% Oxygen 21% Argon 0.95% Carbon Dioxide and trace gases 0.05%
    b. Oxygen 78% Nitrogen 21% Argon 0.95% Carbon Dioxide 0.05%
    c. Nitrogen 78% Oxygen 21% Argon 0.05% Carbon Dioxide and trace gases 0.95%
    d. Oxygen 78% Nitrogen 21% Argon 0.95% Carbon Dioxide 0.05%

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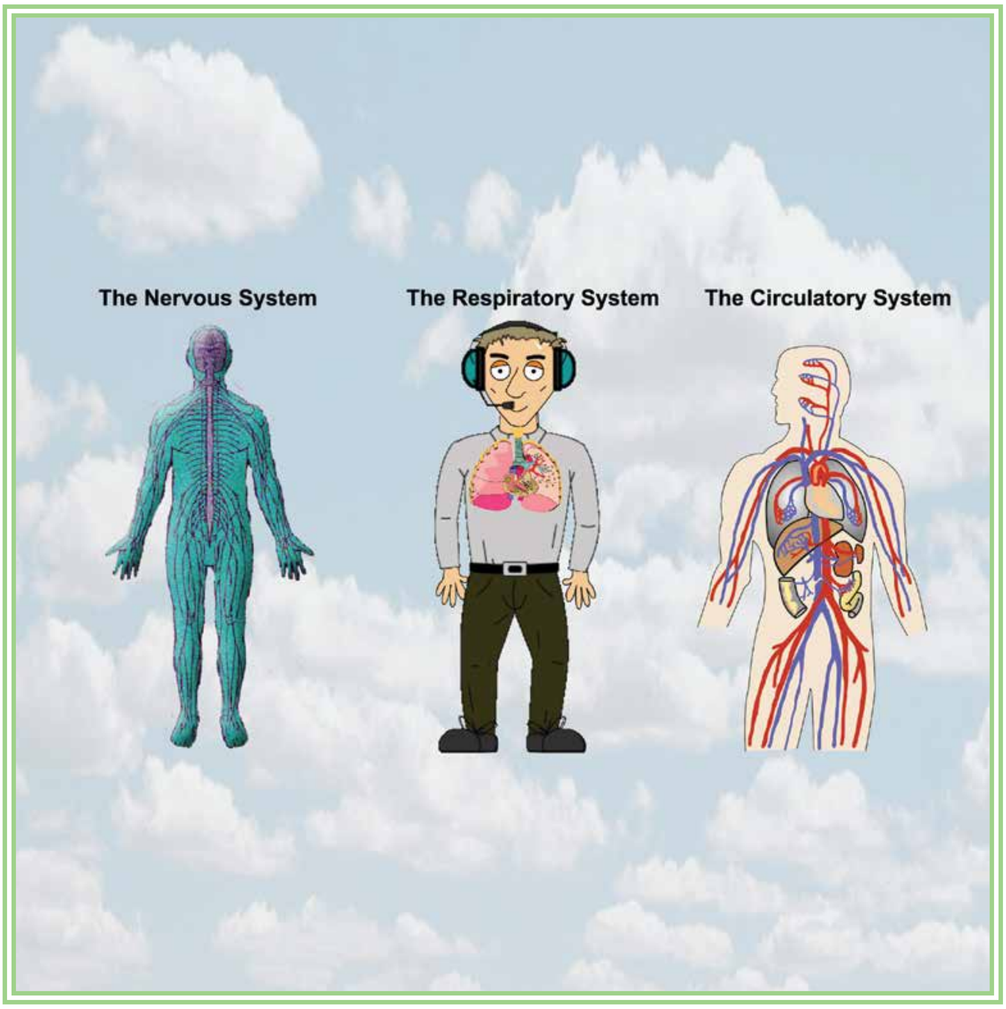
7. At 36 000 feet, the air pressure is:

   a. Three quarters of the sea-level value
   b. Half of the sea-level value
   c. One quarter of the sea-level value
   d. One tenth of the sea-level value

Question	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Answer							

The answers to these questions can be found at the end of this book.

CHAPTER 3
THE HUMAN BODY



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INTRODUCTION.

Human beings live their lives in the lower reaches of the atmosphere. Our bodies are used to the temperatures, pressures and supply of Oxygen that prevail there. In our normal existence we are exposed to normal gravitational force (or acceleration) which we sense through the weight of our body.

In normal life, too, unless we have a very stressful job, our bodies do not have to function under conditions of abnormal stress or very high work loads. The judgements and decisions we take from minute to minute do not normally determine whether we live or die. Even if we are taking medically prescribed drugs or medicines we can usually carry on as normal.

These conditions and assumptions which apply to our every day life on the ground do not always hold true when we are piloting an aircraft. While steady cruising flight below 10 000 feet imposes no unusual conditions or stresses on our bodies, flight at altitudes over 10 000 feet and the practice of aerobatics expose the body to conditions and forces not met on the ground. Cockpit workload can be high, especially in an emergency, bad weather, or when flying on instruments, as well as critical phases of flight such as landing.

Pilots, therefore, need to learn how the human body reacts both physiologically and psychologically to the effects of stress, altitude and variations in "g" forces.

Consequently, the safe and efficient pilot needs a good basic understanding of how the human body functions under normal conditions, and under the conditions that the body may be subject to, and stresses it may have to endure, in flight.

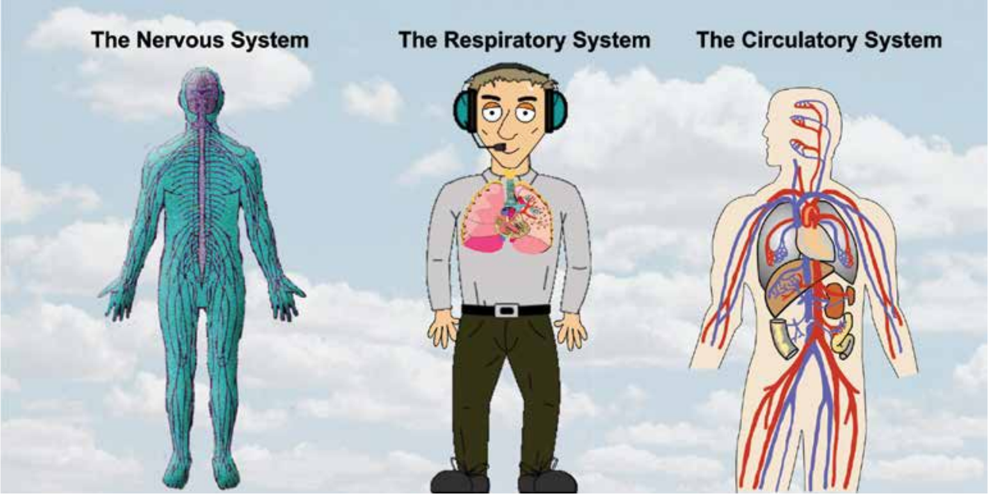

Figure 3.1 The Nervous, Respiratory and Circulatory Systems.

In Human Performance and Limitations, our study of the body will concentrate on the functioning of three of its principal systems:

- **The Nervous System.**
- **The Respiratory System.**
- **The Circulatory System.**

THE NERVOUS SYSTEM.

The Nervous System is the most highly developed and delicate of all the body's systems. It correlates and controls all the other systems of the body through a type of electro-chemical communications network of nerve fibres.

At the centre of the nervous system is the brain through which we control all purposeful bodily functions, including decision-making and speech, and where we experience consciousness, vision, hearing, taste, smell, thought and memory. All these activities and experiences go towards making up the personality of the individual human being.

Our main interest with the nervous system is with our senses, situational awareness, decision-making and stress tolerance. But it will be useful to consider briefly the general architecture of the nervous system.

The nervous system is divided into three main parts:

The nervous system is divided into three main parts: Central, Peripheral and Autonomic.

- **The Central Nervous System.**
- **The Peripheral Nervous System.**
- **The Autonomic (or self-controlling) Nervous System.**

The Central Nervous System.

The Central Nervous System (CNS) consists of the brain and the spinal cord. It is the brain which analyses and interprets the sensory data fed into it from the rest of the Nervous System.

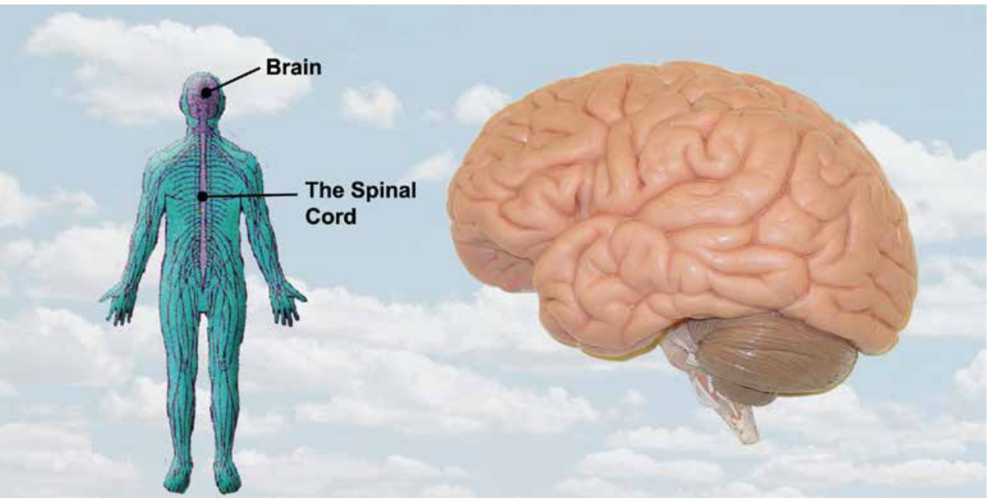

Figure 3.2 The Central Nervous System consisting of the Brain and the Spinal Cord.

The Peripheral Nervous System.

The Peripheral Nervous System connects the central nervous system to the various organs and muscles of the body through sensory nerves and motor nerves. Sensory nerves relay information to the CNS from the organs and muscles. Motor nerves pass information from the CNS to the organs and muscles.

The Peripheral Nervous System regulates all the purposeful and reflex actions carried

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out by the body’s organs and muscles. Sensory impulses travelling toward the brain have their beginnings in various peripheral structures such as the skin, muscles, joints, and special organs like the eye and the ear.

The senses of sight and hearing are of such importance to pilots that they will be considered in dedicated lessons.

The Autonomic (or self-controlling) Nervous System.

The Autonomic (or self-controlling) Nervous System is an involuntary system that largely exercises its functions independently of the Central Nervous System, although the two systems are influenced by one another, as in the case of breathing. Other functions regulated by the Autonomic Nervous System are:

- Arterial pressure.
- Gastrointestinal motions.
- Urinary output.
- Sweating.
- Body temperature.
- Fight or flight response or reaction to stress.

We shall return to the nervous system in later chapters when we deal with vision, hearing, balance, situational awareness, decision-making and stress tolerance.

THE RESPIRATORY SYSTEM.

In order to function correctly, Oxygen is required by all the cells and tissues of the body. For example, brain cells will die if they are deprived of Oxygen for as little as two minutes.

It is the respiratory system *(see Figure 3.3)* which, through the act of breathing, ensures the transference of Oxygen from the atmosphere to the cells and tissues, and of Carbon Dioxide from the tissues back to the atmosphere. Both transfers occur through minute cells called alveoli.

Nitrogen is also absorbed by the body during respiration but plays no role in bodily processes. It does play an important role, however, in the onset of decompression sickness.

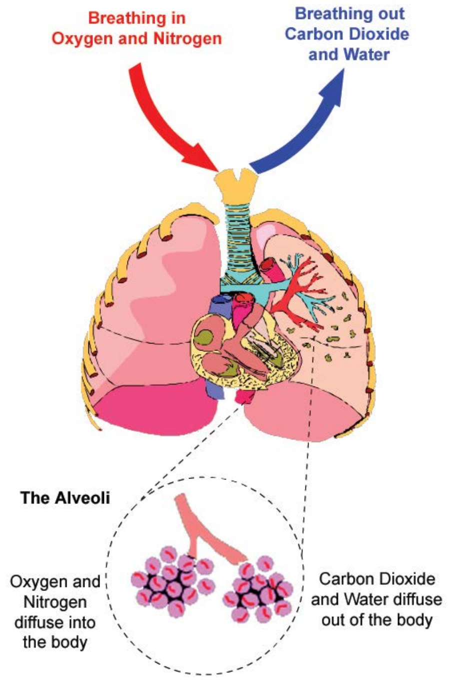

Figure 3.3 The Respiratory System.

External Respiration.

External respiration is the absorption of Oxygen from the air into the blood and the excretion of Carbon Dioxide from the blood into the air. This takes place in the lungs.

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Internal or Tissue Respiration.

Internal or tissue respiration refers to the transfer of Oxygen from the blood to the tissues of the body. At the same time, the tissues give up Carbon Dioxide to the blood. This exchange takes place through the walls of the capillaries. We can see, then, that the blood circulation system, which we shall be considering later, plays a vital role in maintaining the respiratory process.

Breathing.

Breathing is largely governed by the body monitoring changes in the level of Carbon Dioxide in the blood.

Normal breathing is a purely automatic process under the unconscious control of the Autonomic Nervous System, although for short periods the rate and depth of respiration can be controlled at will. The normal rate of respiration in adults is 14 to 18 breaths per minute. The respiratory centre is especially sensitive to the amount of Carbon Dioxide (CO_2) in the blood. The level of CO_2 in the blood effectively regulates the rate and depth of breathing in order that the concentration of CO_2 in the blood remains constant.

We shall return to the subject of respiration in the chapter on ‘Effects of Partial Pressure’, where, amongst other things, we will learn about the effects of altitude, hypoxia, hyperventilation, and rapid decompression.

THE CIRCULATORY SYSTEM.

In order to function properly, indeed, in order to live at all, the organs and tissues of our body must receive an adequate supply of nourishment and Oxygen and be able to expel the waste products which result from their activities. This vital process is carried out by the blood.

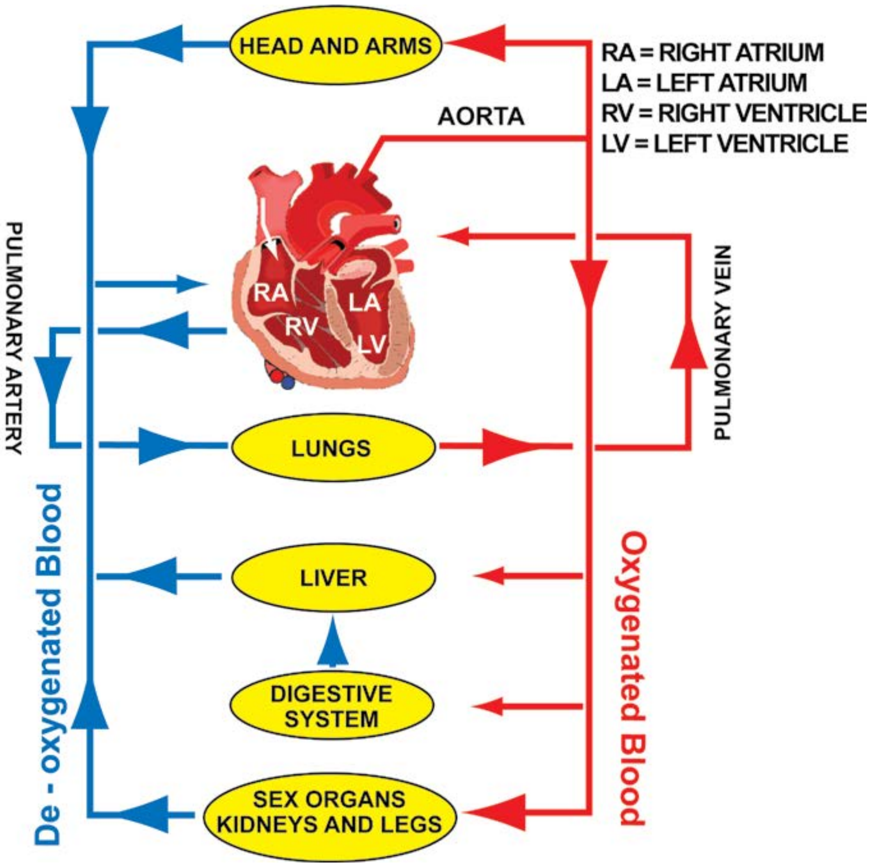

Figure 3.4 The Circulatory System.

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The blood circulatory system is the mechanism that maintains the constant circulation of blood throughout the body. This mechanism consists of the heart and the various types of blood vessels.

The Heart.

The heart is located in the chest cavity. It is about the size of a clenched fist and is the ‘power house’ or pump of the circulatory system.

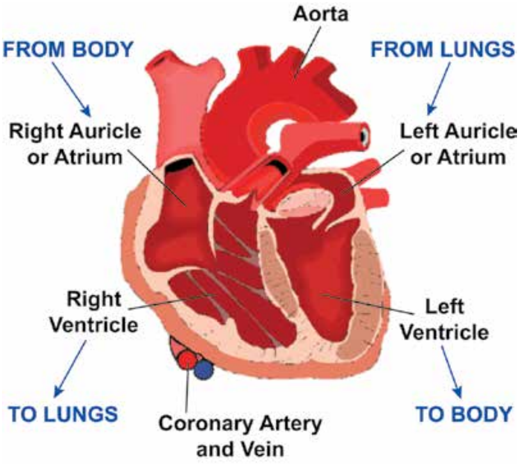

Figure 3.5 The Human Heart.

As can be seen from *Figure 3.5*, the heart has four chambers: two ventricles and two auricles, or atria. The atria act as receiving chambers for the pump and the ventricles are the distributors which propel the blood through the lungs and circulatory system.

The aorta is the main artery of the body and is the channel through which the blood leaves the left ventricle.

Leading into and out of the heart are various blood vessels: the arteries which carry blood from the heart at high pressure and the veins which return blood to the heart at low pressure. As the heart itself is a muscle, it requires its own blood supply system which is provided by the coronary arteries and veins.

Narrowing or blockage of the coronary arteries or veins is the cause of one of the major diseases which may affect the heart.

Oxygen is obtained from the atmosphere and the blood picks up the Oxygen from the lungs for transport around the body. Blood containing Oxygen is pumped around the body from the left ventricle. A system of one-way valves in the heart prevents blood going the wrong way.

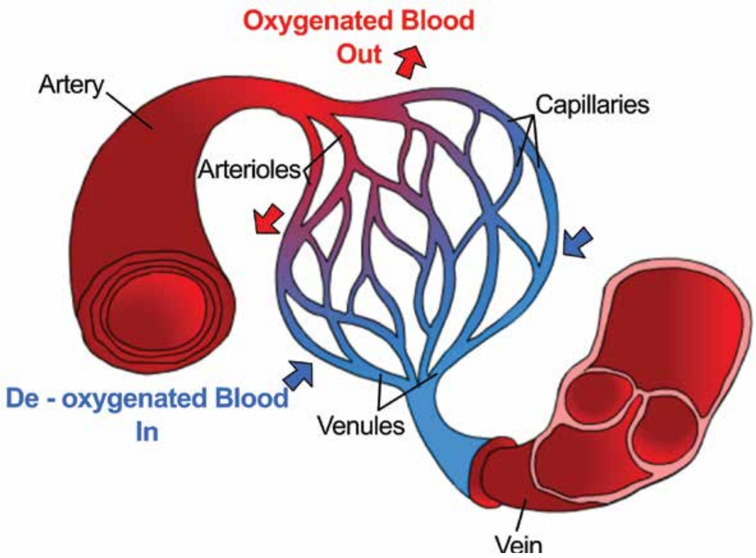

Figure 3.6 Capillaries.

The oxygenated blood passes through the aorta into the major arteries which divide into the smaller arteries before arriving at the smallest vessels of the system - the capillaries.

The capillaries have very thin walls only one cell thick which allow the passage of Oxygen from the blood into the tissues, by diffusion *(see Figure 3.6)*. They also allow Carbon Dioxide and water vapour to diffuse in the reverse direction. This exchange can only take place via the capillaries. Even the smallest arteries and veins have walls too thick to allow diffusion.

De-oxygenated blood passes from the venous capillaries to veins, which progressively increase in size, and return eventually to the right atrium. It then passes to the right ventricle which pumps the blood via the pulmonary artery to the lungs. (This is the only artery in the body that carries ‘dirty blood’, i.e. blood with a blue tinge).

The Carbon Dioxide and water in the blood are released to the lungs and, at the same time, the blood is re-oxygenated. The blood then returns to the heart via the pulmonary vein and left auricle (This is the only vein in the body which carries clean blood with a large supply of Oxygen in it, i.e. blood with a red tinge). The blood is then pumped back into the aorta by the left ventricle.

The Pulse.

Each time the left ventricle contracts it forces blood into the aorta causing a wave or expansion to spread over the whole of the arterial system, gradually dying away as it reaches the capillaries.

This wave or expansion constitutes the pulse which can be felt in the superficial arteries of the body. The normal rate of the pulse is the rate of the heartbeat. A healthy adult, at rest, has a pulse rate of between 60 and 80 beats per minute.

Pulse rate is increased by exercise, emotional disturbances and disease. For instance, when the body experiences stress or fear, adrenaline is released into the bloodstream causing an immediate increase in the pulse rate.

Blood pressure.

Blood pressure is the pressure which the blood exerts on the walls of the main arteries. When an artery is cut it can be seen that, in addition to the continuous stream of blood flowing out under high pressure from the end nearest the heart, there are regular spurts of increased pressure corresponding with each heart beat.

The permanent pressure, the lower of the two pressures, is called Diastolic Pressure.

The increased pressure occurring with each beat of the heart is called the Systolic Pressure. *(See Figure 3.7)*.

Blood pressure is measured in millimetres of Mercury. Blood Pressure is expressed as two numbers: the Systolic Pressure being mentioned first, followed by the Diastolic Pressure: for example, 120/80. 120/80 is a normal blood pressure for a healthy, young adult.

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Blood Pressure:

Systolic Pressure is the high value pressure when the heart contracts.

Diastolic Pressure is the low value pressure when the heart relaxes.

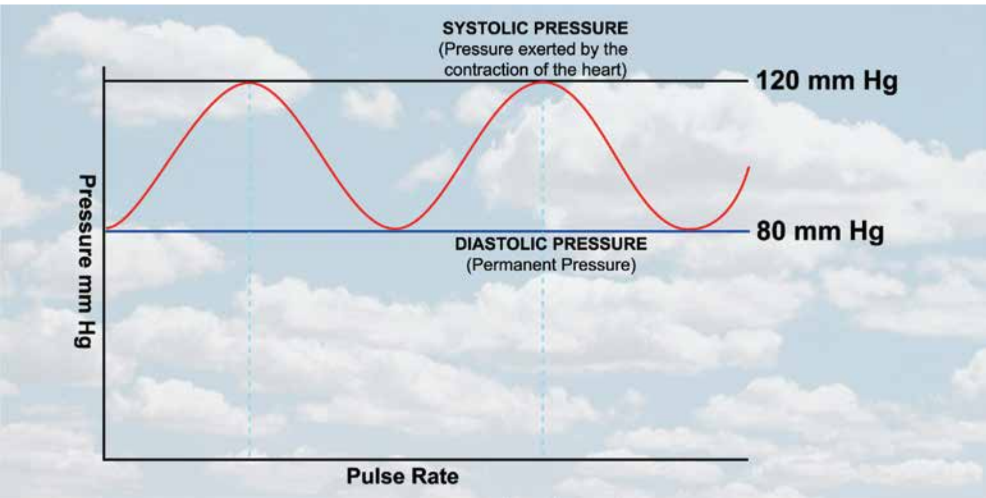

Figure 3.7 Blood Pressure Graph showing Systolic and Diastolic Pressure.

The maintenance of a normal blood pressure is necessary to good health. Low blood pressure can be symptomatic of heart failure or shock. But it is high blood pressure, or hypertension, rather than low blood pressure which is a major cause of unfitness in pilots. High blood pressure can cause blood vessels to burst, especially in the brain, causing a stroke.

JAA regulations stipulate that a pilot with a blood pressure of 160/95 is unfit to fly.

High blood pressure is difficult to detect without specialist measuring equipment. Possible causes of high blood pressure are as follows:

- Stress.
- Smoking.
- Poor diet (excess fat and/or salt).
- Obesity.
- Lack of exercise.
- Age.
- Narrowing of the arteries.

Pilots should not fly for 24 hours after giving blood.

Donating Blood.

Like many people, pilots may wish to donate blood. However, in order to prevent the very slight risk of post-transfusion faintness, it is recommended that, after giving blood, pilots rest supine (lying down) for up to 20 minutes and drink plenty of fluids.

It is important to note that pilots should not fly within 24 hours of giving blood.

Figure 3.8 Donating Blood.

COMPOSITION AND FUNCTION OF THE BLOOD.

We have already learnt that the blood plays an essential role in the maintenance of life. It carries Oxygen and other nutrients to the body's tissues and organs and removes their waste products.

The body of an average adult contains about 6 litres, or 10 pints of blood, which constitutes about one twentieth of total body-weight.

Plasma.

Plasma, a yellowish fluid, is the liquid part of the blood in which float the blood cells or corpuscles. The plasma delivers digested food products such as glucose and amino acids, dissolved proteins, various hormones and enzymes. The plasma also contains salt. You may have noticed that blood tastes slightly salty.

Red blood cells contain Haemoglobin.

Blood Cells.

The blood cells are of three types:

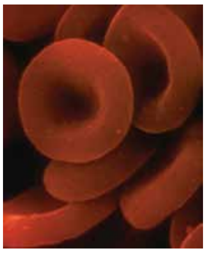

Figure 3.9
Red Blood Cells.

Red blood cells.

Red blood cells contain haemoglobin, and carry Oxygen to the cells and tissues of the body.

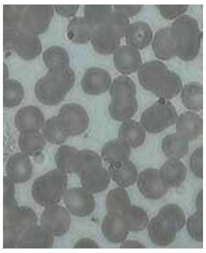

Figure 3.10
White Blood Cells.

White blood cells.

The main function of white blood cells is the defence against disease. They produce antibodies to fight viruses.

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Figure 3.11
Platelets.

Platelets.

Platelets are the smallest of the blood cells. They assist in the blood clotting process.

The Principal Functions of the Blood.

The principal functions of the blood are to:

- carry Oxygen to, and Carbon Dioxide from the various tissues and organs of the body.
- carry nutrients to tissues and remove waste products from these tissues.
- carry chemical messengers, such as hormones including adrenaline, to regulate the actions and secretions of various organs.
- transport cells which can attack and destroy invading micro-organisms enabling the body to resist disease.
- assist in temperature control of the body.

FAILURES OR MALFUNCTIONS OF THE CIRCULATORY SYSTEM.

The Circulatory System can malfunction in two principal ways:

- The main components of the system, the heart and the blood vessels, may develop a fault.
- The blood may become unable to carry enough Oxygen for the needs of the organs and tissues of the body.

Angina and Heart Attack.

Like all other organs and tissues, the heart muscles require Oxygen to continue working. This Oxygen is carried to the heart by the coronary arteries. If a narrowing of these vessels should occur, insufficient blood may reach the heart muscle.

This lack of Oxygen, particularly when the heart is beating faster due to exercise or stress, may give rise to the symptoms of Angina: pain in the chest and arms.

If the blood supply is cut off completely, a portion of the heart muscle may die (that is, suffer an infarct). The heart beat may become irregular or even fail completely, the sufferer experiencing a heart attack.

Angina is caused by insufficient blood and, therefore, Oxygen reaching the heart muscle.

Among the factors predisposing a human being to the risk of angina or heart attack, and which may be mitigated by medical treatment or change of life-style, are:

- High blood pressure.
- Raised blood cholesterol.
- Smoking and lack of exercise.

Other factors, such as stress, obesity, alcohol and certain dietary considerations, are less clearly understood.

Insufficiency of Oxygen Carriage by the Blood.

Body organs and tissues may be deprived of the Oxygen they need because of illness or disease. For instance, the blood of a sufferer of anaemia contains insufficient haemoglobin or red blood cells, for reasons that go beyond the scope of this book.

A pilot suffering from hypoxia (inadequate Oxygen supply) may quickly be unable to guarantee the safety of his aircraft and passengers. Both his intellectual and sensory judgement will be impaired. If serious Oxygen deprivation continues, the pilot will become unconscious and die within minutes.

For instance, at 25 000 feet, without a supply of supplementary Oxygen, a pilot would become unconscious within 3 minutes. Hypoxia will be dealt with in the chapter entitled ‘The Effects of Partial Pressure’.

Incapacitation in Flight.

The dramatic and sudden incapacitation of a pilot during flight is extremely uncommon and very rarely the cause of an accident. Regular medical examinations minimize the risk of total incapacitation due to heart disease, epilepsy etc. As the pilot grows older the frequency of medical checks increases.

Electrocardiogram recordings are used more and more with advancing age in order to spot those at risk.

Carbon Monoxide Poisoning.

Haemoglobin has an affinity for Carbon Monoxide 210 times greater than that for Oxygen.

Figure 3.12 A Carbon Monoxide Detector.

As you have learnt, it is the red blood cells which carry Oxygen to the body’s organs and tissues. It is haemoglobin, within the red cells, which is the main vehicle of Oxygen transportation.

However, haemoglobin has a much greater affinity with Carbon Monoxide than with Oxygen and so, when Carbon Monoxide is present in the air that the body breathes in, the haemoglobin will transport that gas in preference to Oxygen. Carbon Monoxide, of course, is harmful to the tissues and organs. 5 to 10% of the exhaust gases from reciprocating engines is Carbon Monoxide. So, gases from leaking exhausts, which may enter an aircraft's cabin, especially through the heater, and be breathed in by the pilot, will expose the pilot to the dangers of Carbon Monoxide poisoning. Carbon Monoxide is odourless and colourless, which adds significantly to its dangers. Its effects are also cumulative, so the chances are that a pilot will not immediately recognise the danger he is in.

A pilot could fly in an aircraft in the morning with a defective heater, land, have lunch, then fly the same aircraft again. The ingested Carbon Monoxide from the morning trip will still be present in the pilot's body during the afternoon trip.

Consequently, Carbon Monoxide detectors are fitted to the instrument panels of many light aircraft. These detectors become discoloured if Carbon Monoxide is present in the cabin.

Symptoms of Carbon Monoxide Poisoning:

Among the symptoms of Carbon Monoxide poisoning are:

- Headache.
- Dizziness.
- Nausea.
- Impaired vision.
- Lethargy or weakness.
- Impaired judgement.
- Personality change.
- Impaired memory.
- Flushed cheeks and cherry-red lips.
- Convulsions.

Action to be Taken if Carbon Monoxide Poisoning is Suspected.

If a pilot suspects that he or his passengers are displaying the symptoms of Carbon Monoxide poisoning, or if the Carbon Monoxide detector becomes discoloured, immediate action needs to be taken.

Recommended immediate actions are:

- Turn off cabin heating.
- Open cabin ventilators.
- Consider using Oxygen if available.
- Land as soon as possible.

If Carbon Monoxide poisoning is suspected, a pilot will not be fit to fly again for several days.

If a pilot has inhaled exhaust gases over a prolonged period during flight he will not be fit to fly again for several days.

AT ALL TIMES WHEN THE CABIN HEATING IS USED IT SHOULD BE DONE SO IN CONJUNCTION WITH THE USE OF FRESH AIR.

SMOKING.

A smoker will feel the symptoms of hypoxia at a lower altitude than a non-smoker.

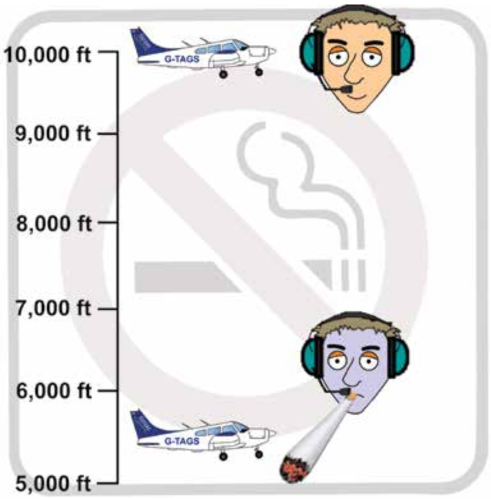

Figure 3.13 Pilots who smoke have a lower Oxygen-carrying capacity.

Smoking tobacco produces Carbon Monoxide which links with the haemoglobin in the blood to deny Oxygen carriage. The circulatory system of a pilot smoking 20 cigarettes a day may experience a reduction in Oxygen-carrying capacity which puts him at an equivalent altitude of 4,000 to 5,000 feet higher than that at which he is actually flying.

So a pilot who is also a smoker may experience the symptoms of Oxygen deprivation, or Hypoxia, at a lower altitude than a non-smoker. He will also have increased susceptibility to Carbon Monoxide poisoning.

Other dangers of smoking are:

- Lung cancer.
- Circulatory problems.
- Reduced tolerance to ‘g’ forces.
- Increased risk of heart attack.
- Degradation of night vision.

ALCOHOL CONSUMPTION.

Alcohol is not really a stimulant. It acts primarily as a depressant on the nervous system with some critical areas of the brain being especially vulnerable. By depressing the highest centres of the brain, alcohol diminishes an individual’s powers of self-control, self-consciousness and anxiety.

Alcohol is not digested into the human body. It is absorbed directly from the stomach and intestines into the bloodstream. From there it is carried to every portion of the body. The liver is then responsible for eliminating the alcohol. The liver does this by changing the alcohol into water and Carbon Dioxide. Drunkenness occurs when the individual drinks alcohol faster than the liver can dispose of it.

It takes on average one hour for one unit of alcohol to be eliminated from the blood.

Taking half a pint of beer, a standard glass of wine or a tot of spirit as being one unit of alcohol, we may assume that alcohol is only slowly broken down by the body and

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eliminated from the blood at a rate of approximately one unit per hour, though that rate may vary from individual to individual.

The consumption of 1½ pints of beer or three single whiskies will result in a blood/alcohol level of about 45-50 milligrams of alcohol per 100 millilitres of blood, and so it will take 3 - 4 hours for the blood level to return to normal.

Consumption of alcohol above certain levels can cause permanent damage to the body. The recommended maximum levels are as follows:

- For men - three units daily or 21 units per week.
- For women - two units daily or 14 units per week.

The generally accepted levels of alcohol consumption, beyond which significant damage may occur to the body, are 21 units per week for men and 14 units per week for women.

Research has shown that blood/alcohol concentrations of 40 milligrams per 100 millilitres (half the current legal driving limit) are associated with significant increases in errors committed by pilots. The following are the effects on the body that the consumption of even small amounts of alcohol may have:

- Impaired judgement.
- Impaired ability to reason.
- Degraded muscular co-ordination.
- Lack of inhibitions and self-control resulting in increased recklessness.
- Degraded vision.
- Balance and sensory illusions.
- Disrupted sleep patterns (alcohol degrades REM sleep and causes early waking).
- Heightened susceptibility to Hypoxia.
- Physical damage to the liver, heart, brain and blood cells.
- Disruption of short and long-term memory.
- Slowing of reaction time.
- In addition, a person who has been drinking alcohol may actually perceive that his performance has improved.

Note, too, that at high altitude, where the body breathes in a lower mass of Oxygen per breath, these effects are aggravated.

Increased altitude will aggravate the effects of alcohol consumption.

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What the Authorities say on Alcohol Consumption.

JAR OPS specifies a maximum blood alcohol limit for pilots of 20 milligrams per 100 millilitres of blood.

British regulations advise that pilots should not fly for at least 8 hours after taking small amounts of alcohol and proportionally longer if larger amounts are consumed. They recommend that pilots abstain from alcohol for at least 24 hours before flying.

Mixing the consumption of alcohol and drugs is absolutely prohibited as this can lead to disastrous and unpredictable consequences.

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Representative PPL - type questions to test your theoretical knowledge of The Human Body.

1. Breathing is regulated by:

   a. The will of each human being
   b. The presence of haemoglobin in the blood
   c. Monitoring changes in the level of Carbon Dioxide in the blood
   d. The transfer of Oxygen from the blood to the tissues of the body

2. A smoker will feel the symptoms of hypoxia (Oxygen starvation) at:

   a. A lower altitude than a non-smoker
   b. A higher altitude than a non-smoker
   c. The same altitude as a non-smoker
   d. Smoking makes no difference to a person’s susceptibility to hypoxia

3. On average, how long does it take to eliminate one unit of alcohol from the blood?

   a. 24 hours
   b. 12 hours
   c. One hour
   d. 8 hours

4. The mechanism that maintains a constant flow of blood around the body is called:

   a. The Respiratory System
   b. The Reproduction System
   c. The Nervous System
   d. The Circulatory System

5. How long after prolonged breathing-in of Carbon Monoxide must a pilot refrain from flying?

   a. 8 hours
   b. 12 hours
   c. Several days
   d. 24 hours

6. Pilots should not fly within …. hours of donating blood.

   a. 12
   b. 24
   c. 36
   d. 48

7. The main function of the red blood cells is to:

   a. Carry Oxygen to the tissues
   b. Assist in the clotting process
   c. Produce antibodies to fight infection
   d. Deliver digested food products to the tissues

8. Angina is caused by:

   a. Death of part of the heart muscle
   b. A blockage of pulmonary blood vessels
   c. Insufficient blood reaching the heart muscle
   d. A blocked blood vessel in the brain

9. Carbon monoxide is dangerous because:

   a. Its smell and taste are not easily recognisable to the inexperienced pilot
   b. Haemoglobin has10 times the affinity for it than it has for Oxygen
   c. Haemoglobin has 110 times the affinity for it than it has for Oxygen
   d. Haemoglobin has 210 times the affinity for it than it has for Oxygen

10. The damaging levels of alcohol are 21 units for men and 14 units for women. This is:

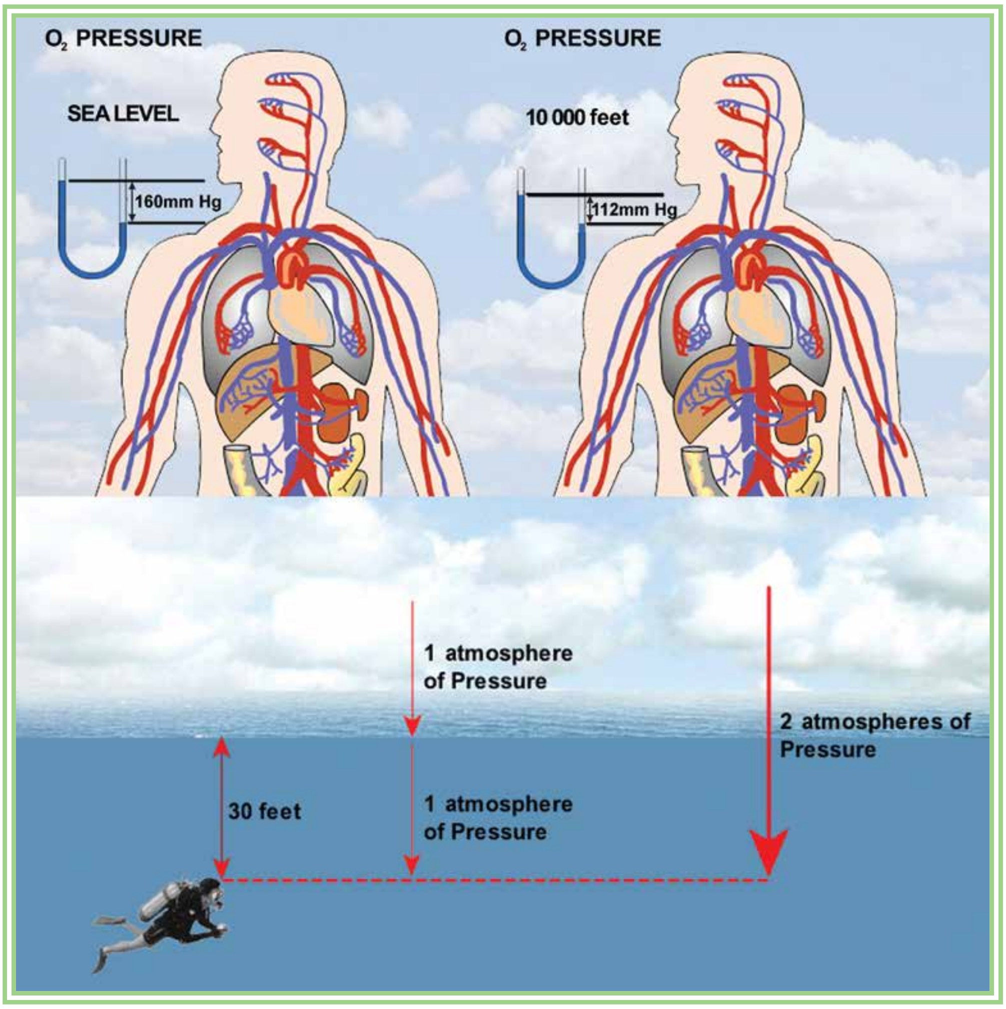
   a. Per day
   b. Per week
   c. Per month
   d. Per year

Question	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Answer										

The answers to these questions can be found at the end of this book.

CHAPTER 4

THE EFFECTS OF PARTIAL PRESSURE



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INTRODUCTION.

You learnt from the chapter on the atmosphere that air pressure decreases with altitude from its ISA sea-level value of 1013.2 hectopascals (760 mm of mercury (Hg)).

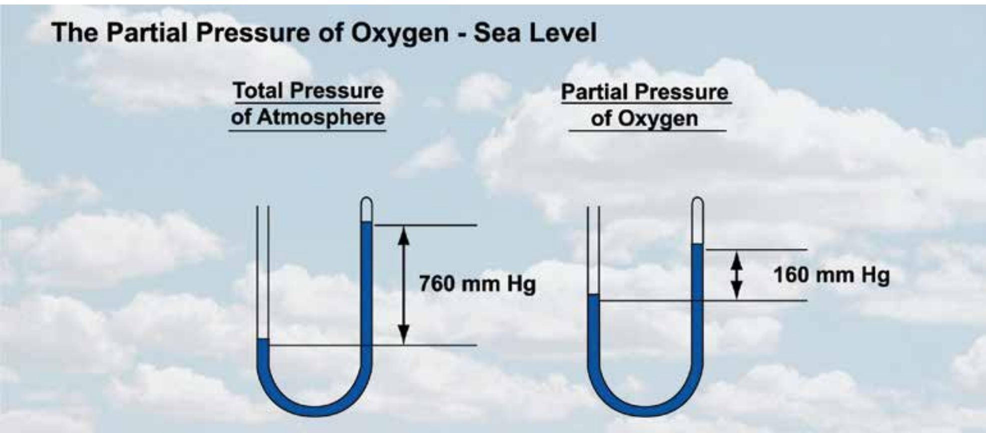

Figure 4.1 The Partial Pressure of Oxygen at Sea-level (ISA).

At 36 000 feet, air pressure measures less than 255 hectopascals (190 mm of mercury (Hg)). This pressure is about ¼ of the sea-level value. You have learnt, too, that whatever the altitude, the proportion of Oxygen in the atmosphere, by volume, always stays the same: that is, about 21%.

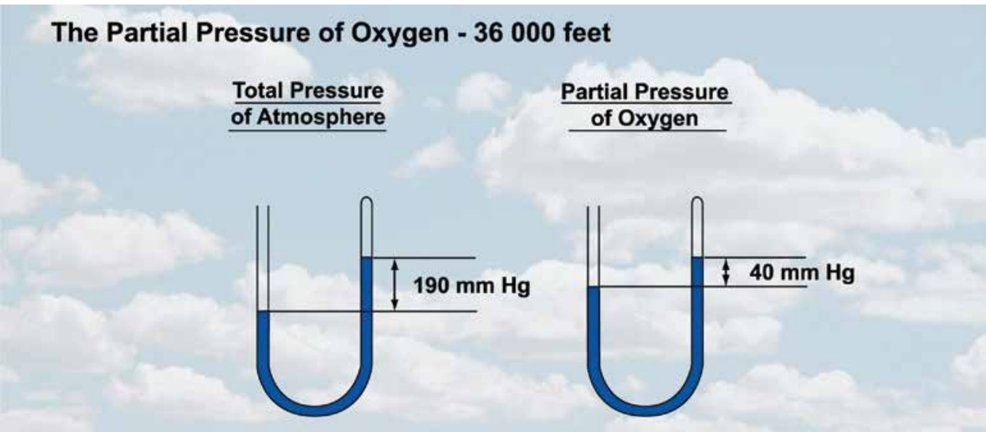

Figure 4.2 Atmospheric Pressure and the Partial Pressure of Oxygen at 36 000 feet.

As the total pressure of air decreases with altitude, the partial pressure of Oxygen decreases, too, from a sea-level value of 160 mm Hg to only 40 mm Hg at 36 000 feet.

Just as the partial pressure of Oxygen decreases with altitude, air density also decreases with increasing altitude. So, as density is defined as mass per unit volume, a given volume of air, say the volume of a human lung, will contain a smaller mass of Oxygen than at sea-level.

Now, the human body is designed to function normally in the lower atmosphere under sea-level values for air pressure and air density.

People who live for long periods at high altitudes, for example in mountainous areas, can adapt to low partial pressures of Oxygen by producing extra red blood cells.

(Athletes frequently train at altitude prior to competing at sea-level. By doing so, their bodies will be rich in red blood cells prior to competition; therefore, their body Oxygen carrying capability will have increased).

But normal, healthy human beings, used to living near sea-level, will need supplementary Oxygen to carry out sustained physical activity at altitudes exceeding about 10 000 feet. The lower air density at high altitudes means that less Oxygen will be taken into the lungs with each breath, compared to sea-level, and the lower partial pressure of the Oxygen will mean that even less Oxygen will diffuse from the lungs into the bloodstream.

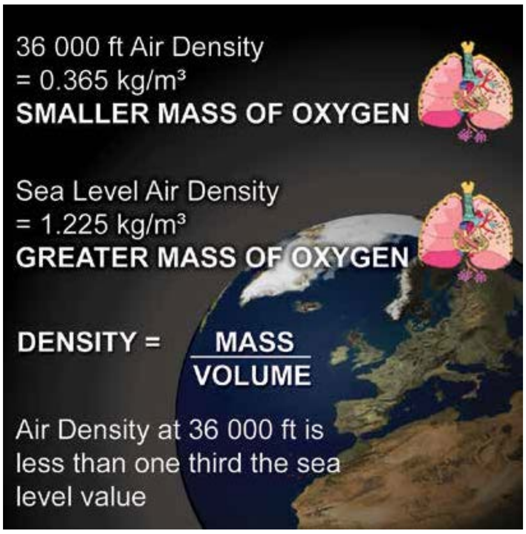

Figure 4.3 Lower air density at altitude means that the lungs take in less Oxygen, per breath.

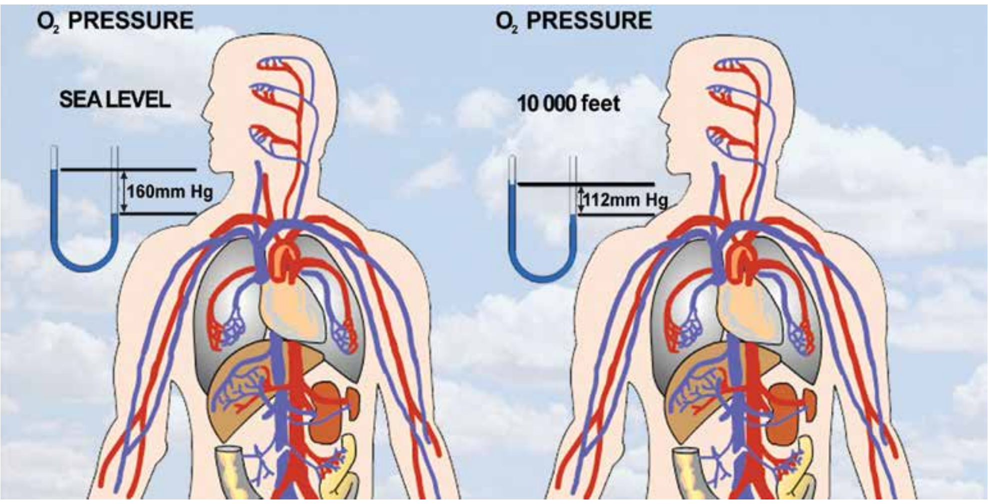

Figure 4.4 The lower partial pressure of Oxygen at altitude means that less Oxygen will diffuse into the bloodstream.

The decrease in atmospheric pressure with altitude leads to a fall in the partial pressure of Oxygen, reducing the amount of Oxygen available to the body.

However, the reduced partial pressure of Oxygen in the air at altitude is not the whole “partial pressure story” of why the body needs supplementary Oxygen. The body actually takes its Oxygen from the alveoli of the lungs where the partial pressure of Oxygen is even less than in the atmospheric air, owing to the presence of higher levels of Carbon Dioxide and water vapour in the air in the lungs. As the total pressure of air both inside and outside the lungs remains the same, at any given altitude, the partial pressure of Oxygen in the lungs must be further reduced. The table overleaf shows the partial pressures of the various gases in the atmosphere, and in the alveoli at sea-level, and 10 000 feet.

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Partial Pressures in the Atmosphere and in the Lungs (mmHg)

Constituents	Oxygen	Nitrogen	Water Vapour	CO_2
At Mean Sea-Level				
Atmospheric Air	160 (21%)	600	Negligible	Negligible
Alveolar Air	103 (14%)	570	47	40
At 10 000 feet				
Atmospheric Air	104 (21%)	419	Negligible	Negligible
Alveolar Air	55 (10.5%)	381	47	40

A partial pressure of 55 mm Hg of Oxygen is considered the minimum for normal bodily function. So at altitudes greater than 10 000 feet, a pilot needs to breathe supplementary Oxygen. Supplementary Oxygen should, ideally, be sufficient to maintain an alveolar Oxygen partial pressure of 103 mm Hg, which is equivalent to breathing air at sea-level.

Pilots should normally begin breathing supplementary Oxygen from 10 000 feet above sea-level. As altitude increases still further, the supply of supplementary Oxygen must likewise increase. At about 34 000 feet, pilots require 100% Oxygen.

As we have established, pilots can operate with an alveolar Oxygen partial pressure of 55 mm Hg. So, what would happen if a pilot were to continue to climb his aircraft beyond 34 000 feet while breathing 100% Oxygen?

Well, the partial pressure of Oxygen in the lungs would begin to decrease again until, at 40 000 feet, the minimum partial pressure of 55 mm Hg of Oxygen would again be reached within the lungs. Above 40 000 feet, then, Oxygen must be supplied to the pilot through a pressure breathing system. Oxygen is then forced into the lungs, as opposed to the pilot using a “demand-Oxygen” system, as at lower altitudes.

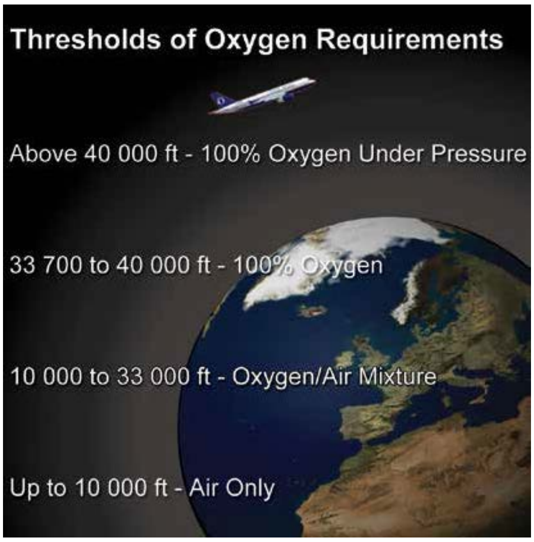

Figure 4.5 Thresholds of Oxygen Requirements.

As you might imagine, it is primarily military pilots flying at very high altitudes who use pressure breathing systems. Military pilots also require specialized training to master those systems.

HYPOXIA (OXYGEN STARVATION).

Hypoxia is the name given to the physical condition in which there is insufficient Oxygen to meet the body’s needs. Technically, a person may suffer from hypoxia because of a number of different causes. Of greatest significance to pilots is “Hypoxic hypoxia”, which is a lack of Oxygen due to altitude.

Hypoxia occurs when there is insufficient Oxygen to meet the body’s needs.

The occupants of an aircraft flying at over 10 000 feet will suffer from hypoxia if they do not breathe supplementary Oxygen or if the supplementary Oxygen supply is faulty. The onset of hypoxia will be more rapid, and its effects more severe, the higher the altitude.

The severity of hypoxia will also increase with an increase of exposure time to lack of Oxygen.

The adverse effects of hypoxia are further increased if sufferers are involved in physical activity.

Extremes of temperature can also aggravate the effects of hypoxia.

If a passenger has consumed alcohol, that, too, may aggravate the symptoms.

A tobacco smoker is likely to experience the effects of hypoxia at a lower altitude than a non-smoker because smoking reduces the haemoglobin in the blood cells which is necessary to transport Oxygen. A regular smoker may begin to suffer from hypoxia approximately 4 000 feet - 5 000 feet below the altitude at which a non-smoker will be affected.

In order to guard against the onset of hypoxia, it is very important that the crew of an aircraft should begin to breathe supplementary Oxygen above 10 000 feet.

Symptoms of Hypoxia.

It is of vital importance that pilots be able to recognise the symptoms of hypoxia and know what steps to take to eliminate its causes and minimise its effects.

An early symptom of lack of Oxygen is likely to be euphoria (a feeling of well-being). Subsequently, the affected person will experience difficulty in carrying out mental tasks. Various stages of impaired judgement will follow, the symptoms of which may include the following:

- Personality change (euphoria).
- Impaired judgement.
- Headache.
- Tingling in hands and feet.
- Hyperventilation.
- Muscular impairment.
- Sensory loss.
- Tunnel vision.
- Impairment of consciousness.
- Cyanosis (a blueness around the lips and at the finger tips).

When operating at high altitude, impaired judgement, sensory loss, memory loss, loss of consciousness, muscular impairment and personality change will most probably be symptoms of hypoxia.

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The importance of pilots being able to recognise the symptoms of hypoxia cannot be overstated. Early identification of the symptoms will allow the pilot to carry out the appropriate drills in sufficient time to avoid jeopardising the well-being of the aircraft's crew and passengers.

Immediate Actions to be Taken if Hypoxia is Suspected:

Oxygen should be administered immediately to those affected. Then the pilot must descend as quickly as possible to below 10 000 feet, making proper allowances for minimum safe altitudes.

The initial treatment of hypoxia should be to provide the sufferer with Oxygen.

A Pilot In Command must always familiarize himself with the Oxygen drills appropriate to his aircraft and equipment. If a pilot is preparing for flight at altitudes around or exceeding 10 000 feet, he must also, before the flight, ensure that Oxygen equipment is serviceable and that all on board have been appropriately briefed. It is worth checking the serviceability of the cabin heating system, too, to ensure that there are no engine leaks which might lead to Carbon Monoxide entering the cockpit.

Although most private pilots, flying light aircraft, do not operate at very high altitudes, we include below, for your information, a table showing how long it would take for a pilot or passenger to become incapacitated if deprived of supplementary Oxygen, at various altitudes. These times are known as the Time of Useful Consciousness. (In effect, the time a person has at his disposal to take action to help himself.)

Times of Useful Consciousness at Various Altitudes.

Altitude (feet)	**Progressive Decompression**		**Rapid Decompression**
	Sitting	**Moderate Activity**	
18 000	About 40 min	About 30 min	20 - 25 min
20 000	10 min	5 min	3 min
25 000	5 min	3 min	2 min
30 000	1.5 min	45 sec	30 sec
35 000	45 sec	30 sec	20 sec
40 000	25 sec	18 sec	12 sec
45 000	18 sec	12 sec	12 sec

Figure 4.6 Times of Useful Consciousness.

HYPERVENTILATION.

Hyperventilation may be simply defined as "overbreathing". More technically, hyperventilation is lung ventilation in excess of the body's needs, or breathing in excess of the ventilation required to remove Carbon Dioxide from the body.

The onset of hyperventilation denotes an over-riding of the normal automatic control of breathing by the brain. As you have learnt, it is the amount of Carbon Dioxide in the blood which governs breathing. The reduction in Carbon Dioxide which is induced by hyperventilation disturbs the breathing control mechanism.

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Hyperventilation may well be caused by hypoxia, but hypoxia is not the only cause of hyperventilation. It is important to realise that an attack of hyperventilation which is unrelated to hypoxia cannot be treated by breathing Oxygen.

Causes of Hyperventilation.

At low altitudes, where hypoxia may safely be ruled out as a contributory cause, the most common causes of hyperventilation are:

- Anxiety.
- Motion sickness.
- Shock.
- Vibration.
- Heat.
- High g-forces.
- Pressure breathing.

When operating well below 10 000 feet, dizziness, anxiety, a tingling sensation and visual impairment are symptoms of hyperventilation.

Thorough training is the best way for a pilot to avoid the onset of hyperventilation in himself. High standards of training and the cultivation of a deep understanding of flying theory breed confidence and decrease the chances of a pilot getting into dangerous situations or of becoming over-anxious in emergency situations.

As a pilot, make sure that you are aware of nervousness or anxiety in your passengers, and know how to re-assure them. An anxious passenger may even begin to hyperventilate while still on the ground, so make a point of ensuring that passengers are well briefed on every aspect of the flight they are about to undertake. This will help to remove any reason for anxiety that they may have.

Symptoms of Hyperventilation.

The following symptoms of hyperventilation have been identified:

- Obvious rapid breathing.
- Dizziness and a feeling of unreality.
- Tingling – especially in the extremities and lips.
- Visual disturbances –such as blurred, tunnel and clouded vision.
- Anxiety.
- Loss of muscular co-ordination.
- Increased heart rate.
- Spasms in the muscles of the hands, fingers and feet just prior to unconsciousness.
- Loss of consciousness.

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Treatment of Hyperventilation.

In order to treat hyperventilation effectively, it is imperative that you first establish that the condition you are treating is indeed hyperventilation and not hypoxia. In flight, it can be difficult to distinguish between the symptoms of the two conditions.

At altitude, the only appropriate action for a Pilot In Command to take is to assume the worst and to carry out the drills for hypoxia, as this is the condition requiring the more urgent treatment. However, if you are flying below 10 000 feet, hypoxia is unlikely to be suffered by any passenger or crew-member, and hyperventilation may be assumed.

The symptoms of hyperventilation can be alarming, so, if you suspect that occupants of your aircraft are suffering from hyperventilation, an immediate action to take is to try to reassure the afflicted persons and to calm them down. It is also worth giving them a simple task to fulfil that might make them less anxious.

Because one of the direct causes of hyperventilation is a reduction in the Carbon Dioxide level in the blood, hyperventilation may be alleviated by getting the sufferer to breathe into a paper bag. You could try using a standard sick bag which is carried in most aircraft. The immediate effect of taking this action is to increase the blood's Carbon Dioxide level, causing the nervous system to reduce the breathing rate.

DECOMPRESSION.

Light aircraft usually fly at altitudes below 10 000 feet above sea-level. Operating at these low altitudes, ambient atmospheric pressure and pressure variation with height are such that an aircraft's occupants do not normally risk suffering from conditions related to decompression due to pressure changes alone. However, at higher altitudes, and especially when operating above 18 000 feet, reduced atmospheric pressure can lead to problems associated with decompression, notably decompression sickness.

For occupants of an un-pressurised aircraft, the higher the altitude, and the longer the exposure to high altitude, the more likely the onset of decompression sickness becomes. Decompression sickness may occur as low as 18 000 feet if exposure is long enough. However, decompression sickness is unlikely to occur below 14 000 feet.

Airliners and other high-performance aircraft possess cabin-pressurisation systems which ensure that the effective altitude to which aircrew and passengers are exposed is much lower than the altitude at which the aircraft is actually flying.

Ideally, the cabin of a pressurised aircraft should be maintained at sea-level pressure, but this is not achieved in practice because of aircraft weight and fuselage strength limitations. Typically, the pressurisation system of a commercial airliner flying at 30 000 feet gives an internal cabin pressure equivalent to about 6 000 feet, to 8 000 feet. The pressure differential across the aircraft skin is normally designed not to exceed 8-9 pounds per square inch (psi) *(see Figure 4.7 overleaf)*. The rate of change of cabin pressure while climbing and descending is limited to an equivalent altitude change of 500 feet/min in the ascent and 300 feet/min in the descent.

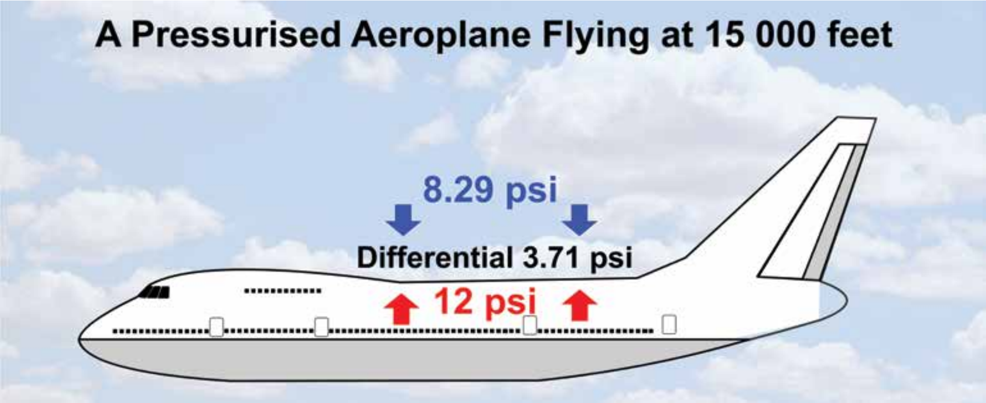


Figure 4.7 Differential Pressure.

DECOMPRESSION SICKNESS.

Under atmospheric conditions, at the Earth's surface, Nitrogen is dissolved in the blood but plays no part in the normal bodily processes. But if, due to a rapid reduction in ambient pressure, the Nitrogen in the blood should come out of solution, as small bubbles, severe physiological problems may occur.

Nitrogen coming out of the blood may be likened to bubble formation in fizzy drinks when the top of the bottle is opened and the pressure allowed to drop. If this occurs in the human body and Nitrogen bubbles are formed in the blood, the process leads directly to decompression sickness.

Symptoms of Decompression Sickness.

The symptoms of decompression sickness in the various parts of the body are as follows:

- ***Joints.***
  Bubbles in the joints cause rheumatic-like pains called the **Bends**. In aviation, the shoulders, wrists, knees and ankles are most commonly affected. Movement or rubbing the affected parts only aggravates the pain, but descent usually resolves the problem.

- ***Skin.***
  Nitrogen bubbles released under the skin cause the **Creeps**, a condition in which the sufferer may imagine that ants are crawling over, or just under, the skin.

- ***Respiratory system.***
  A symptom may develop which is known as the **Chokes**. Nitrogen bubbles may get caught in the capillaries of the lungs, blocking the pulmonary bloodflow. This leads to serious shortness of breath, accompanied by a burning, gnawing and, sometimes, piercing pain.

- ***The Brain.***
  The formation of Nitrogen bubbles affects the blood supply to the brain and the nervous system, leading to an effect known as the **Staggers**. The sufferer will lose some mental functions and control of movement. In extreme cases, chronic paralysis or even permanent mental disturbance may result.

Treatment of Decompression Sickness.

The treatment of decompression sickness involves returning the sufferer to a region of sea-level pressure.

If the symptoms of decompression sickness appear in any passenger or crew member, the pilot should commence an immediate descent to a level at which the symptoms are relieved. The aircraft should then be landed as soon as possible. Meanwhile, the sufferer should be kept warm and rested and put onto a 100% Oxygen supply. Medical assistance must be sought on landing even if the patient appears to have recovered. The ground radio station with which the pilot is in contact should be advised that medical assistance is required.

Decompression sickness is caused by Nitrogen forming bubbles in body tissue.

Obviously, occupants of light aircraft, operating below 10 000 feet above sea-level, are most unlikely to suffer from decompression sickness.

Susceptibility to Decompression Sickness Following Scuba Diving.

However, decompression sickness at low altitude <u>can</u> occur in individuals who have been scuba diving, using compressed-air breathing apparatus, shortly before flying. Air breathed under pressure whilst diving increases the amount of Nitrogen in the body. On subsequent ascent to the water's surface, Nitrogen may come out of solution, giving rise to decompression sickness.

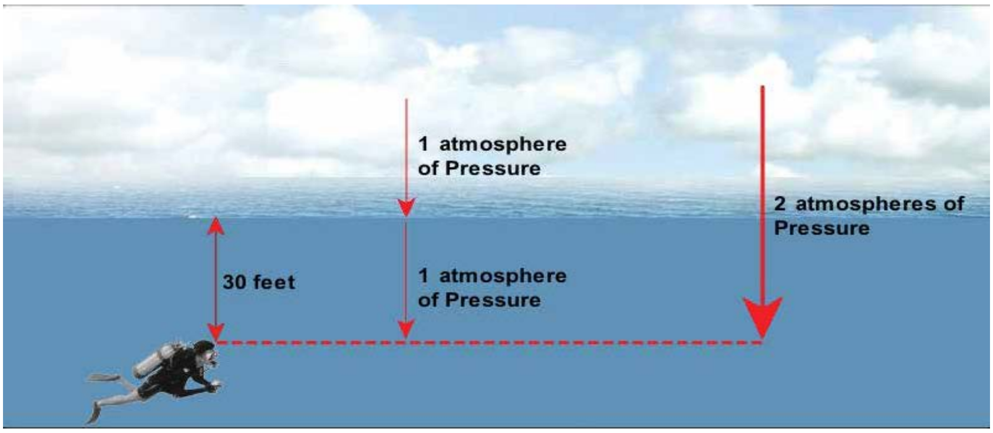


Figure 4.8 Illustration of Atmospheric Pressure at Depth.

The pressure exerted by a 30 feet column of sea water is the same as that exerted by the whole atmosphere at sea-level (i.e. 760 mm Hg). Therefore, a person at a depth of 30 feet is exposed to a pressure of 2 atmospheres (1 atmosphere caused by the air above the water and the other by the water itself) *(see Figure 4.8, above)*. If, after ascending from a depth of 30 feet, a diver were directly to get airborne in a light aircraft, the chances of his suffering decompression sickness would be high.

A pilot must not fly at all within 12 hours of diving and breathing compressed air. A pilot must avoid flying for 24 hours if a depth of 30 feet has been exceeded. Failure to adhere to these rules could result in the onset of decompression sickness at altitudes as low as 6 000 feet.

Do not fly for 24 hours if you have been diving, breathing compressed air, to a depth of 30 feet.

Representative PPL - type questions to test your theoretical knowledge of The Effects of Partial Pressure.

1. Compared to a non-smoker, someone who smokes is likely to experience the effects of hypoxia at:

   a. A higher altitude
   b. The same altitude
   c. A lower altitude
   d. Any altitude

2. The % of Oxygen in the atmosphere, by volume, is:

   a. 21% to an altitude of 10 000 feet
   b. 14% to an altitude of 10 000 feet
   c. 21% to an altitude of 33 700 feet
   d. 21% throughout the atmosphere

3. Hypoxia is defined as:

   a. The condition where there is insufficient Oxygen to meet the body’s needs
   b. The altitude at which a person begins to show symptoms of decompression sickness
   c. The condition where Carbon Monoxide replaces Oxygen in the white cells
   d. The condition where Carbon Dioxide will not bind to haemoglobin

4. At low altitude, the most common symptoms of hyperventilation include:

   a. Anxiety, scuba diving, vibration and poor visual acuity
   b. Feeling of well-being, shock, heat and poor visual acuity
   c. Motion sickness, poor visual acuity, heat and scuba diving
   d. Dizziness, visual disorder, anxiety, tingling around feet, hands and lips

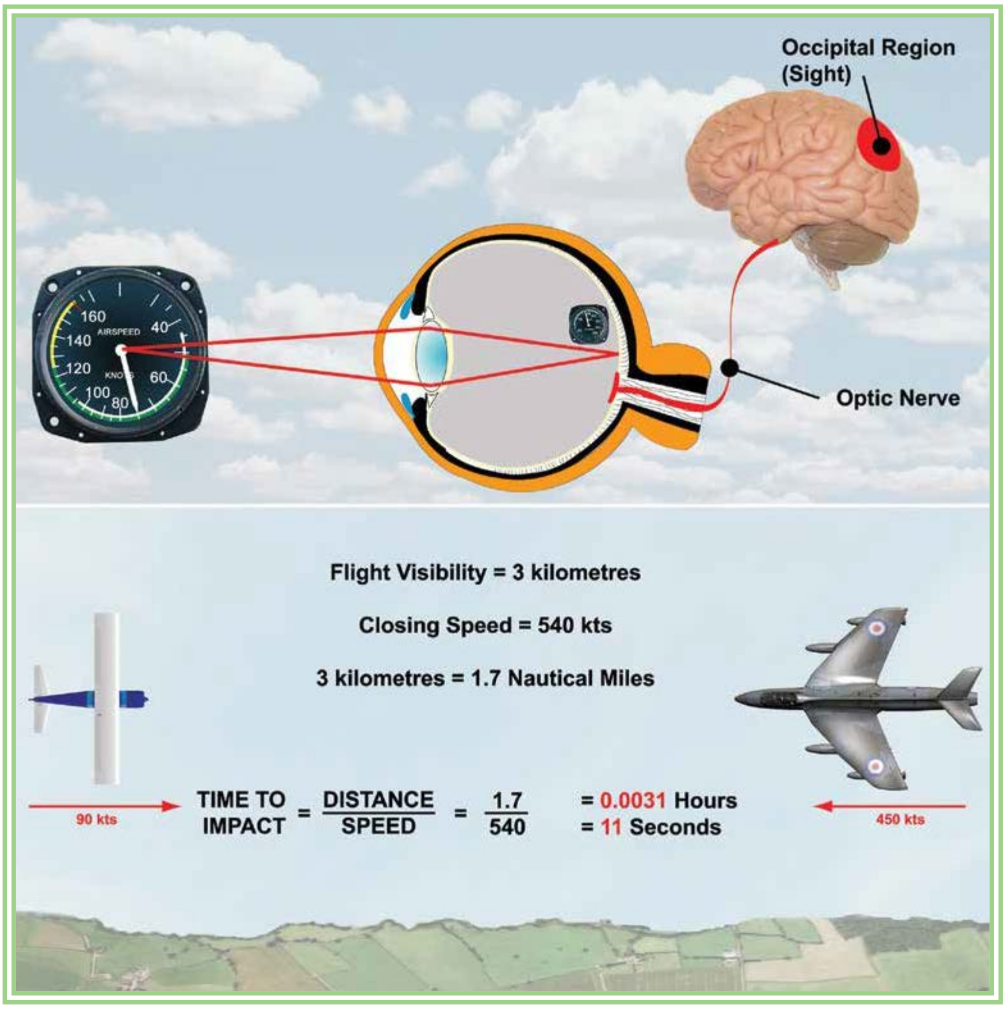
5. You have been diving to a depth of 32 feet using SCUBA pressure breathing equipment:

   a. Do not fly for a period of 12 hours
   b. Do not fly for a period of 24 hours
   c. Do not fly for a period of 48 hours
   d. There is no limitation on when you can next fly

Question	**1**	**2**	**3**	**4**	**5**
Answer					

The answers to these questions can be found at the end of this book.

CHAPTER 5
THE EYE



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THE EYE AND VISION.

The eye delivers to the brain more information about the outside world, and at a much faster rate, than any other sensory organ.

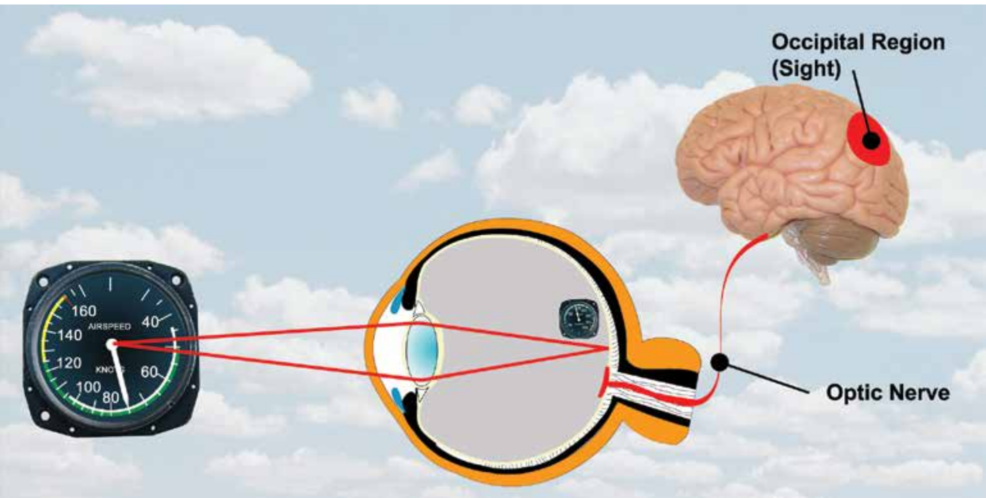

Figure 5.1 The Visual Sensory System.

The eye has 1.2 million neurones leading from the retina to the brain, while there are only about 50 000 neurones between the brain and the inner ear. It is not surprising, then, that, when flying under Visual Flight Rules (VFR) which most PPL holders do most of the time, pilots rely overwhelmingly on their visual perception to fly safely and efficiently. If a VFR-only qualified pilot finds himself in marginal Visual Meteorological Conditions, he can very quickly get into trouble.

We will begin this chapter on vision by looking at the physiology of the eye. The word "physiology" is a technical term meaning the science of the organic functions of animals and plants. The eye is the organ of sight. In fact, it is the most sensitive of all our sensory organs. It is the organ which receives electromagnetic waves within the visual spectrum from the external world and passes them to the brain for interpretation into an image.

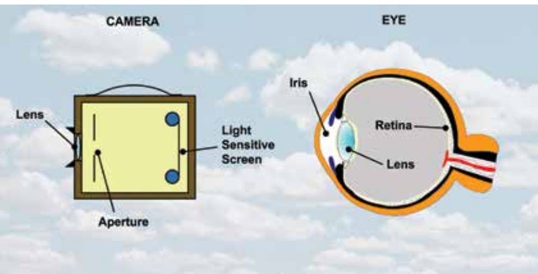

Figure 5.2 Structure of the Eye.

The basic structure of the eye is similar to a simple camera with an aperture called the **iris**, a **lens**, and a light sensitive film called the **retina**. The structure of the eye can be seen in *Figure 5.2* .

The Cornea.

Light enters the eye through the **cornea**, a clear window at the front of the eyeball. The cornea acts as a fixed focussing device and is responsible for between 70% and 80% of the total focussing ability of the eye. The cornea helps focus light onto the retina by bending the incoming light rays.

The Iris and Pupil.

The amount of light entering the eye is controlled by the **iris**, the coloured part of the eye, which acts as a diaphragm. The iris controls the amount of light entering the eye by altering, as necessary, the size of the pupil, the clear centre of the iris. The size of the pupil can change rapidly to cater for changing light levels.

The Lens.

After passing through the pupil, light passes through a clear lens. The lens is the component of the eye which bends the light rays, and focuses them onto the retina. The shape of the lens is changed by the muscles (ciliary muscles) surrounding it. It is the ciliary muscles which enable the final focussing of the light onto the fovea.

The Retina is the light-sensitive part of the eye.

This change of shape of the lens under the action of the ciliary muscles is known as accommodation. The effectiveness of accommodation is influenced by the ageing process or fatigue. When a person is tired, accommodation is diminished, resulting in blurred vision.

The Retina.

The retina is a light-sensitive screen lining the inside of the eyeball. On this screen are light-sensitive cells known as cones and rods, which, when light from an object falls on them, generate a small electrical charge which passes an image of the object to the brain via nerve fibres (neurones) which combine to form the optic nerve. The image formed on the retina is inverted, but is perceived “right-way-up” by the brain.

Cones and Rods.

Cones are used for direct vision, in good light, and are colour-sensitive, capable of distinguishing approximately 1 000 different shades of colour. The rods can only detect black and white but are much more sensitive at lower light levels. As light decreases, the sensing task is passed over from the cones to the rods. This means that, in poor light levels, we see only in black or white, or varying shades of grey. Rods are responsible for our peripheral vision.

The Fovea.

The Fovea is the area of greatest visual acuity.

The central part of the retina, the fovea, contains only cones. Any object which needs to be examined in detail is automatically brought to focus on the fovea. The fovea is the area of greatest visual acuity on the retina.

The Blind Spot.

In each eye there is a small area in which the blood vessels supplying Oxygen to the retina, and where the nerves forming one end of the optic nerve, are concentrated. This is the blind spot *(see Figures 5.2 and 5.3)*. An image falling on the blind spot of an eye is not detected by the brain, but the image will almost certainly be detected by the other eye.

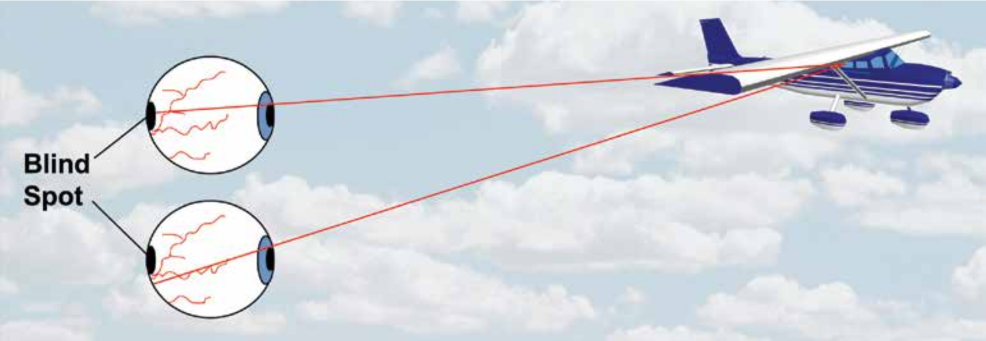

Figure 5.3 The image of the aircraft falls on the blind spot of one eye, but is “seen” by the other eye.

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Central Vision and Visual Acuity.

The rest of the retina fulfils the function of attracting our attention to movement and change. Only at the fovea can vision be of normal visual acuity, 20/20 or 6/6. This clear vision is termed central vision.

Each eye is equipped with muscles which enable the eyeballs to rotate in their sockets, thus enabling them to keep track of a moving object. To track an object successfully, or to focus on an object, the eyes need to move in harmony with one another. This means that the brain must co-ordinate control of the muscles of the two eyes.

Binocular vision refers to the fact that two eyes are required for a complete visual capability. We need binocular vision to create for us a three-dimensional picture of the world.

Visual acuity is a measure of central vision. Visual acuity is the capacity of the eye to determine small detail, undistorted, at a given distance. The sharpest visual acuity occurs when the object being viewed is sharply focused on the fovea.

A person with 20/20 or 6/6 vision is said to have normal visual acuity. The figures 20/40 (or 6/12) mean that the observer can only read at 20 feet what a person with normal vision can read at 40 feet (or at 6 metres what a person with normal vision can read at 12 metres).

Normal visual acuity permits pilots to detect objects clearly at safe distances. If a person's vision with the naked eye is impaired, this will not normally prevent that person from becoming a pilot, provided normal visual acuity can be achieved by wearing spectacles or contact lenses.

Whereas normal visual acuity is required to see objects clearly at a distance, good near-vision, too, is necessary for a pilot to read instruments and maps. Being able to focus on close objects is a function of the eye's ability to accommodate. The power of accommodation usually diminishes in middle age, but can easily be corrected by wearing reading glasses. Pilots and drivers normally wear bi-focal spectacles to allow them to see clearly at a distance and to read their instruments and maps.

The sharpness of central vision, that is the image at the fovea, drops as light falls on the retina at increasing angles from the fovea. At as little as 5° from the fovea, visual acuity drops to 20/40. That is only half as good as the visual acuity at the fovea. At approximately 25 degrees, visual acuity decreases to a tenth of its normal performance (20/200).

Limitations of Visual Acuity.

Visual acuity is limited or impaired by the following factors:

- Angular distance from the fovea.
- Physical imperfections within the visual system.
- Age.
- Hypoxia.
- Smoking.

- Alcohol.
- Atmospheric visibility (dust, mist etc. in the air will reduce visibility).
- Light intensity.
- Size and contours of an object.
- Distance of the object from the viewer.
- Contrast of an object with its surroundings.
- Relative motion of a moving object.
- Drugs or medication.

Night Vision.

To see an object best at night, look slightly to one side of it.

If a person has been in bright light for a long time, the sensitivity of the eye to light is greatly reduced. Thus, passing from a brightly lit room into the dark of night has the effect of vision being severely reduced until dark adaptation takes place.

On the other hand, if the person remains in darkness for a long time, the eye becomes super-sensitive to light so that even the faintest amount of light can irritate the retina and dazzle the person concerned. The eye adjusts more quickly to this second occurrence than to the first. This is why it is especially important for pilots to allow sufficient time for dark adaption to take place before flying at night. It takes time for our eyes to adapt to darkness: about 7 minutes for the cones and 30 minutes for the rods.

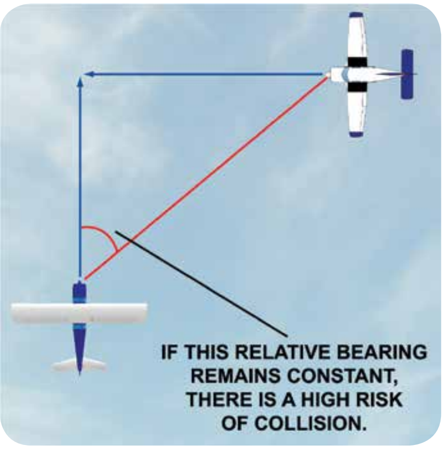
As you have learnt, rods are very sensitive to poor light, but see only shades of black and white. They also give us our peripheral vision. Thus, as the fovea contains no rods, this area of best visual acuity is virtually blind in dim light conditions such as those which prevail at night. At night, to achieve maximum visual acuity, it is advisable to look slightly to one side of the object so that the light falls onto a part of the retina where there are rods. This is a good technique to use when night flying.

You can demonstrate this technique to yourself by looking at dim stars on a clear night. Though they may appear extremely faint if you look directly at them, they will be more clearly discernible if you look slightly off to one side.

THE BLIND SPOT.

An aircraft on a constant relative bearing to you may be on a collision course, and is difficult to spot.

As described earlier, each eye has an area on the retina where there are no light sensors, called the blind spot. This has great significance when considering the detection of objects which are on a constant relative bearing from the observer. If the eye remains looking straight ahead, it is possible for a closing aircraft to remain in the blind spot until a very short time before impact.



IF THIS RELATIVE BEARING REMAINS CONSTANT, THERE IS A HIGH RISK OF COLLISION.

Figure 5.4.

This is because an aircraft on a constant relative bearing from you will not change its relative position to you. Furthermore, the fact that the other aircraft is not moving is a sure sign that you are on a collision course with it. Of course, if the aircraft is in your blind spot, the collision danger is compounded.

With both eyes un-obscured, the blind spot is not a problem, as each eye is able to cover an object which might be in the other eye's blind spot. However, if the approaching aircraft is on a constant bearing, the pilot may not see it, if it remains in the blind spot of one eye and an object, e.g. windscreen or pillar, within the cockpit, is obscuring the aircraft from the pilot's other eye. *(See Figure 5.5)*

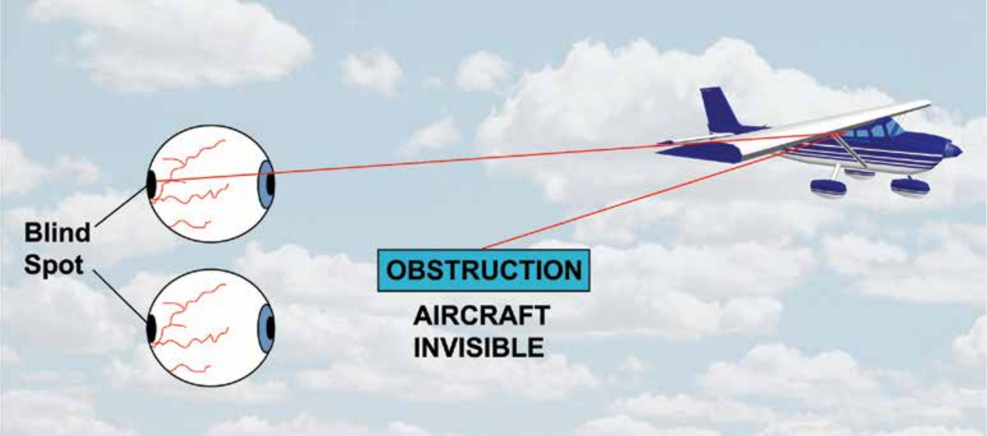


Figure 5.5.

To lessen the danger of collision and to put into practice the VFR precept of "see and be seen", pilots are taught to carry out a systematic look-out at all times. A systematic look-out involves moving the head to look out of the cockpit to the left and right sides, as well as overhead. Safe visual scanning demands frequent eye movement with minimal time spent looking at a single patch of sky.

Make sure you carry out a constant scan of the air space around you.

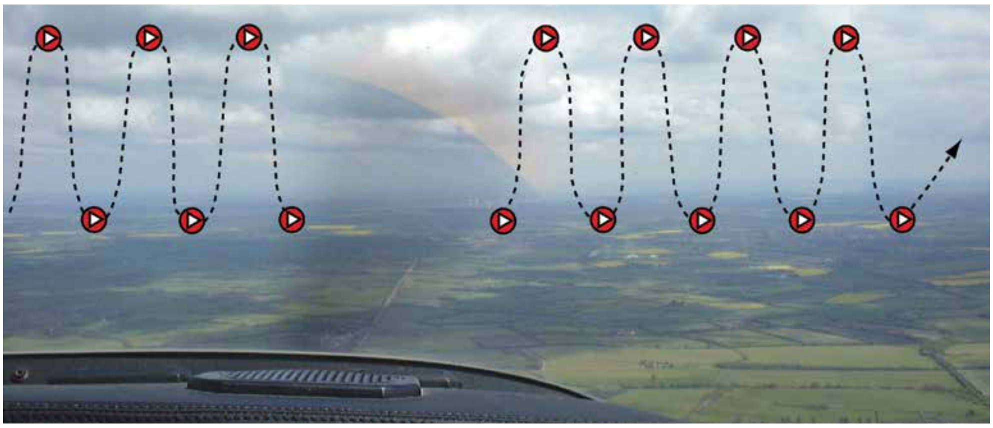


Figure 5.6 An Effective Scanning Method.

An effective scanning method, especially in a low-wing monoplane, is to look out to one side of the aircraft, to just behind the trailing edge of the wing, and sweep the gaze forwards, looking above and below the horizon *(See Figure 5.6).* The pilot should, then, repeat this action in the other direction before checking overhead. Head and eye movements should be co-ordinated in order to cover as much of the visual field as possible.

EMPTY FIELD MYOPIA.

In the absence of anything to focus on, the natural focal point of the eye is not at infinity, as was long assumed, but, on average, at a distance of between one and two metres in front of the eye. This condition is called Empty Field Myopia.

This near-field focussing can be significant for a pilot, who may be searching for distant contacts when visual cues are weak, as the eye will not adjust to detect them. The condition can be aggravated when there are other objects close to the empty field range, such as rain spots or dirt specks on the windscreen. The eye will naturally be drawn to such objects.

Empty Field Myopia is most likely to occur in cloudless skies, at high altitudes, in total darkness, under a uniformly overcast sky, or when resting the eyes. Pilots should be aware of the risks associated with an empty visual field and periodically and deliberately focus on objects, both close and at a distance, thus exercising the eyes.

THE USE OF SUNGLASSES.

Very high light levels occur at altitude where light may be reflected from cloud and where there is less scattering of the light rays by the atmosphere.

Normal sunlight contains all the colours of the spectrum but, at high altitudes, pilots are exposed to light that contains more of the high-energy blue and ultra-violet wavelengths than is experienced at sea-level . The higher energy blue light can cause cumulative damage to the retina over a long period. Ultra-violet wavelengths can also cause damage, mainly to the lens of the eye, but most ultra-violet wavelengths are filtered out by the cockpit windows.

Wearing appropriate sunglasses can provide further protection against high levels of light, but make sure you avoid using cheap sunglasses as these can allow the light to be over-diffused across the eye, thus causing perceptual problems in flight. The use of polaroid sunglasses should be avoided since problems can occur when polaroid sunglasses are used with laminated aircraft-windscreens.

Light sensitive lenses (photochromic) are also generally forbidden for use in flight due to the time taken for the lens to clear when moving from a bright situation to one of low light. This delay may significantly reduce visual acuity at a critical time.

Sunglasses suitable for wear in flight should have the following characteristics:

- Be impact resistant.
- Have thin metal frames (minimum visual obstruction).
- Be coated with polycarbonate for strength.
- Be of good optical quality (refractive Class 1).
- Have a luminance transmittance of 10 -15%.
- Possess appropriate filtration characteristics.

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VISUAL DEFECTS.

The most common visual defects are caused by the distorted shape of the eyeball. Other defects are due to irregularities in the cornea, the lens and the eyeball itself.

Myopia.

Myopia is more commonly known as short-sightedness. The normal eye is practically spherical and, when the lens and ciliary muscles are relaxed, the image of a distant object will fall on the retina. In a myopic eye, the eyeball is longer than normal. This fact causes the images from distant objects to fall in front of the retina. Thus, distant objects will be out of focus for a short-sighted person.

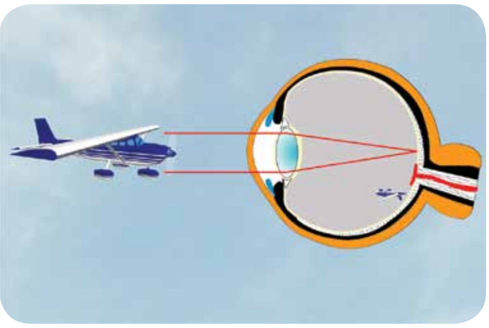

Figure 5.7 The normal eye.

Myopia results from an elongated eyeball. It can be corrected with concave lenses.

A concave lens will correct myopic vision by bending or refracting the light from distant objects outwards before it hits the cornea.

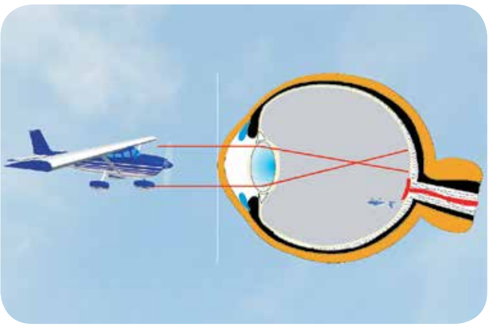

Figure 5.8 In myopia, the eyeball is longer than normal.

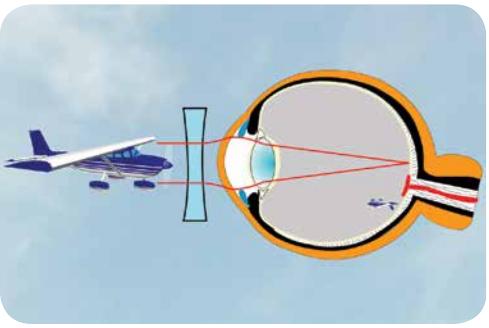

Figure 5.9 Myopia can be corrected with a concave lens.

Normal distance vision for pilots may be very approximately assessed as the ability to read a car-number plate at 40 metres. For the United Kingdom driving test, the distance required is 23 metres.

Hypermetropia.

In long-sightedness, or, in medical terms, hypermetropia, a shorter than normal eyeball results in images being formed behind the retina.

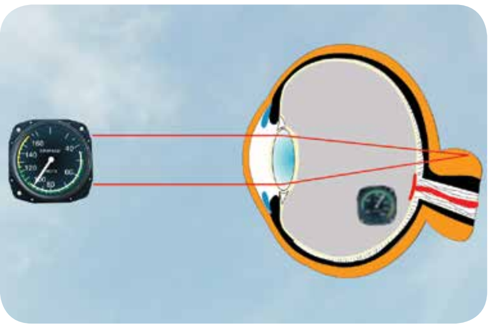

Figure 5.10 Hypermetropia.

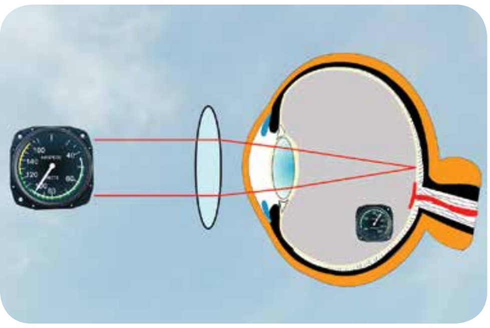

Figure 5.11 A Convex Lens Will Correct Hypermetropia.

Hypermetropia, or long-sightedness is caused by a shortened eyeball. Hypermetropia can be corrected by the use of convex lenses.

A person with hypermetropia can often see distant objects clearly by accommodating slightly. However, he is unable to focus on close objects because the power of the ciliary muscles to change the shape of the lens to achieve accommodation is insufficient for this purpose. Thus, a blurring of the vision will result when looking at close objects.

A convex lens will overcome hypermetropia by bending or refracting the light rays from a close object inwards, before they meet the cornea.

Presbyopia.

The ability of the lens to change its shape and accommodate adequately, thereby focussing the images of close objects on the retina, depends on the elasticity of the lens. Normally, this elasticity is gradually lost with age.

After the age of 40 to 50, the lens is often unable to accommodate fully and a form of long-sightedness known as Presbyopia occurs. The effects of presbyopia manifest themselves as difficulty in reading small print in poor light. The condition normally requires a minor correction with a weak convex lens. Half lenses or "look-over spectacles" will suffice. Pilots who are also myopic will require bi-focal spectacles.

Astigmatism.

The surface of a healthy cornea is hemispherical in shape. Astigmatism is usually caused by a mis-shapen cornea. Although astigmatism can be cured by the use of cylindrical lenses, modern surgical techniques can reshape the cornea with a scalpel or, more easily, with laser techniques. An Authorized Medical Examiner (AME) must be consulted before any corrective surgery or laser treatment takes place for astigmatism, or any other eye condition.

The Wearing of Spectacles by Pilots.

It is convenient to note at this point that pilots who wear corrective spectacles or contact lenses for whatever reason must carry a spare pair of spectacles at all times when they are exercising the privileges of their licence. The choice of spectacles and contact lenses for flying is an extremely important one and should always be made after consultation with your doctor and/or optician. Good advice may be obtained from an authorised medical examiner or the CAA.

Colour Blindness.

Good colour vision is essential for pilots because of the use of colour associated with the following equipment and fittings:

- Navigation lights of aircraft.
- Runways and airfields.
- Ground obstructions.
- Cockpit displays and instruments.
- Maps and charts.
- Emergency flares.
- Light signals.

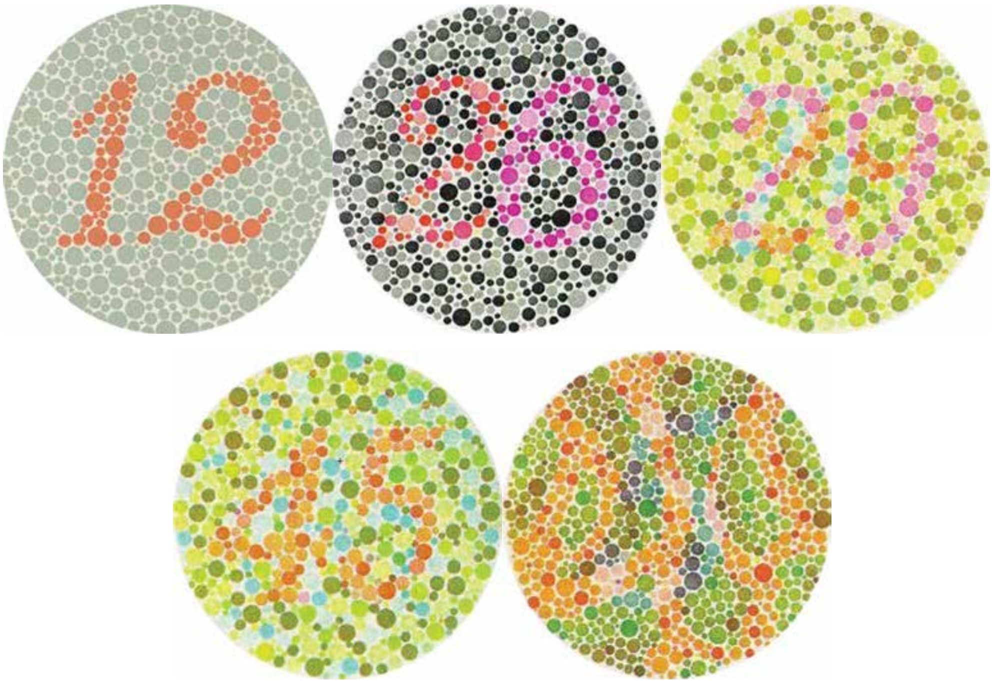

Figure 5.12 Colour-blindness test examples.

Colour-blindness or, more accurately expressed, **colour-defective vision**, is caused by a defect in the structure of the colour-sensitive **cones** in the retina - normally when a single-colour sensitive group is missing. Whereas total colour blindness is extremely rare, many people suffer from colour-defective vision to a degree. The most common form of colour-defective vision is red/green blindness. These colours are seen in shades of yellow, brown or grey.

Figure 5.12 shows a few extracts from a colour vision test. The numbers you see, or do not see, in the colour patterns will depend on the accuracy of your perception of colour.

Do not draw any conclusions from what you see. Your doctor will advise you about your colour perception. Colour-defective vision does not affect visual acuity. Many people go through their lives with no knowledge that they suffer from this visual imperfection.

Colour-blindness is rare in women. However, women do act as carriers of this incurable and congenital flaw.

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VISION AND THE PILOT'S REACTION TIME.

Light aircraft flown by the majority of PPL holders cruise at speeds in the range of 90 knots to 140 knots. Faced with the extreme situation, therefore, of another light aircraft approaching head on, a possible closing speed could be as high as 280kts, (i.e. the sum of the speeds of the individual aircraft). *(See Figure 5.13.)*

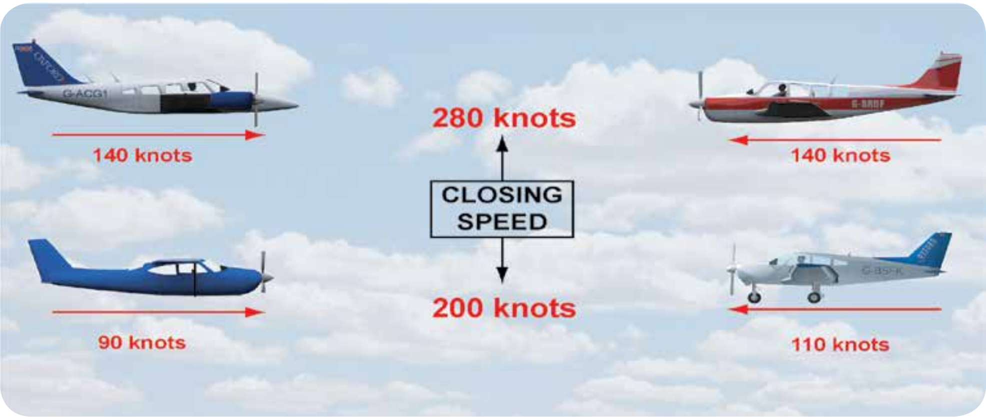


Figure 5.13 Closing Speeds.

The problem of closing speeds of this magnitude is how to take avoiding action sufficiently rapidly to be able to prevent a collision. If a collision is to be avoided, the reaction time of the pilots must be less than the time it would take for the aircraft to come together.

The total reaction time in a pilot is a function of the time taken for all the separate recognition and reaction processes to take place. These processes may be summarised as:

- Visual input.
- Brain reaction.
- Recognition.
- Perception.
- Evaluation.
- Decision.
- Response.

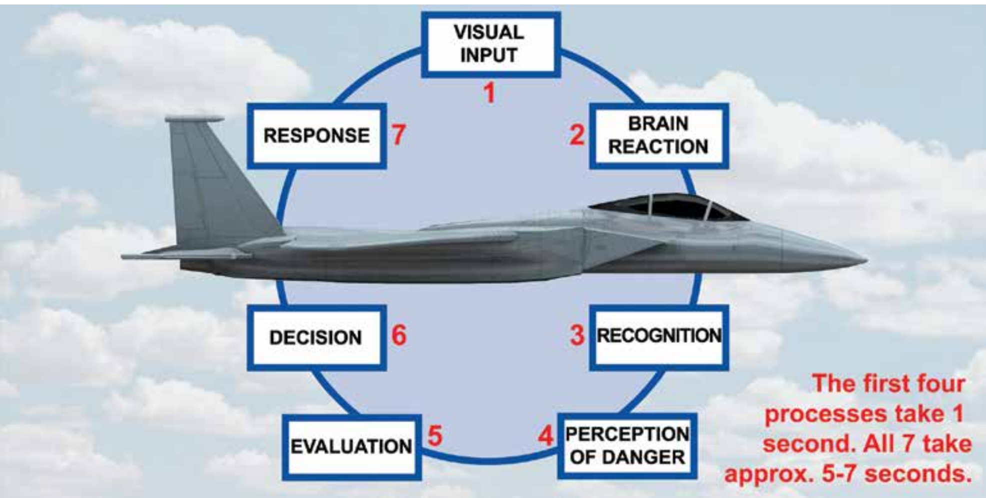
These processes are illustrated in *Figure 5.14.*

In perfect conditions, all these processes take approximately 5-7 seconds to complete. The first four processes take approximately 1 second to complete.

Times may be extended by factors such as:

- Workload.
- Fatigue.

- Poor atmospheric conditions.
- Darkness.
- Size and contrast of object.
- Angular approach.



The first four processes take 1 second. All 7 take approx. 5-7 seconds.

Figure 5.14 Reaction Times.

Time-to-Impact Calculations.

In any event, as a practical consideration, it is extremely useful for a pilot to be able to estimate how long it would take for aircraft on a collision course to close to impact. The important factor is the closing speed; that is, for two aircraft on a head-on collision course, the sum of their individual airspeeds. We can already appreciate that two light aircraft might be approaching collision at anything between 180 knots and 280 knots. If one of those aircraft is a jet, closing speeds will be much higher.

Low-flying military fast jets may be flying at a speed of 450 knots. So, if the aircraft approaching a light aircraft, head-on, is a fast jet, closing speeds may be in the order of 600 knots. We will carry out a few calculations to illustrate the "time-to-collision" of various aircraft approaching each other head-on.

Of course, visual acuity matters enormously when a collision hazard is present. Early detection gives the pilot more time to take avoiding action.

The calculation we need to make to work out "time-to-collision" is simple. Speed is measured in knots, miles per hour, kilometres per hour, metres per second, feet per minute and so on. In every case, though, speed is measured as distance divided by time.

$$\textbf{speed} = \frac{\textbf{distance}}{\textbf{time}}$$

By simple mathematical transposition, this basic equation can be expressed as time equals distance divided by speed:

$$\textbf{time} = \frac{\textbf{distance}}{\textbf{speed}}$$

All we have to do to calculate time, then, is to divide distance by speed. Care must be taken, though, to ensure the correct units for distance, speed and time are used.

Have a look at the situation illustrated in *Figure 5.15*. If the closing speed is given in miles per hour and the distance in miles, as in the diagram, the formula we have obtained will give us a time to impact, in hours. In this case, we have 0.013 hours.

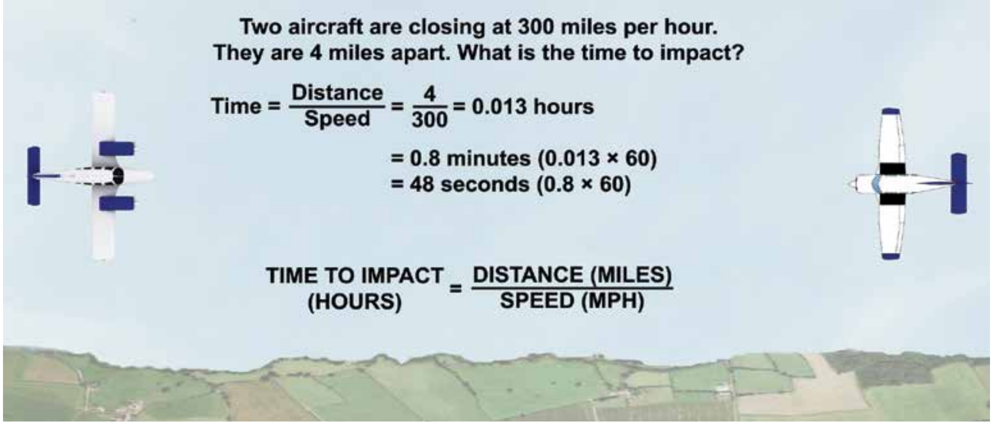


Figure 5.15 Time/Speed/Distance Calculations.

But 0.013 hours is a meaningless figure for us. If we wanted the closing time in minutes we would have to multiply the answer in hours by 60. If we wanted the closing time in seconds, which is much more sensible, we would have to multiply the answer in hours by 60 × 60. We finally arrive, then, at the sensible answer of a time-to-impact of 48 seconds.

In our example then, the closing time was in hours, because the speed was in miles per hour and the distance was in miles. Had the speed been given in knots (nautical miles per hour), the distance would have to have been in nautical miles for the formula to give us the time in hours.

Thus, if you are given mixed units such as speed in miles per hour and distance in, say, kilometres, you would either have to convert the speed into kilometres per hour or the distance into miles.

Time-to-Impact Examples.

Example 1. *(See Figure 5.16 overleaf)*
Two light aircraft are on a head-on collision course with a closing speed of 200 knots. Flight visibility is 4 kilometres. What would be the time available to either pilot to take avoiding action, if visual contact were made at maximum visual range?

Step One. We note that the closing speed is in knots (nautical miles per hour), but that the distance at which visual contact is made is in kilometres.

Step Two. We must, therefore, convert one of the units so that speed and distance units match. Thus, we either have to change speed into kilometres/hour or the distance into nautical miles. Here, we convert kilometres into nautical miles. You can do this using the flight navigation computer.

4 kilometres = 2.16 nautical miles

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Appreciate how little time is available for collision avoidance, when aircraft are approaching head-on.

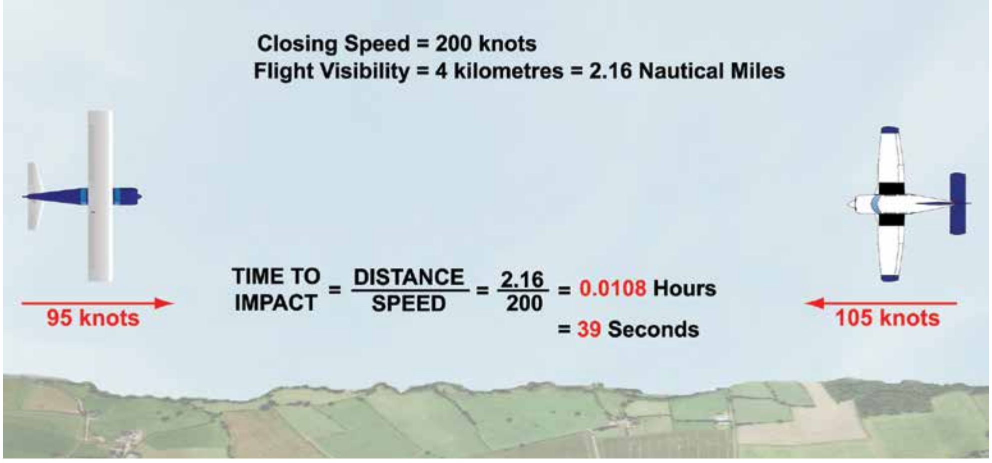

Figure 5.16.

Step Three. We now insert the figures into the formula,

$$\textbf{Time} = \frac{\textbf{Distance}}{\textbf{Speed}} = \frac{\textbf{2.16}}{\textbf{200}} \textbf{ = 0.0108 hours = 39 seconds}$$

The formula gives us 0.0108. Remember that this answer is in hours. To convert this answer, we multiply by 60 to give minutes and by 60 again to give seconds. The answer, thus, becomes 38.88 seconds, which we can round up to 39 seconds.

Example 2. *(See Figure 5.17)*
With an in-flight visibility of 5 kilometres, a light aircraft flying at 120 knots sees a fast jet at maximum visual range. The light aircraft pilot assumes that the fast jet is flying at 450 knots. What time would be left to the pilot of either aircraft to take avoiding action?

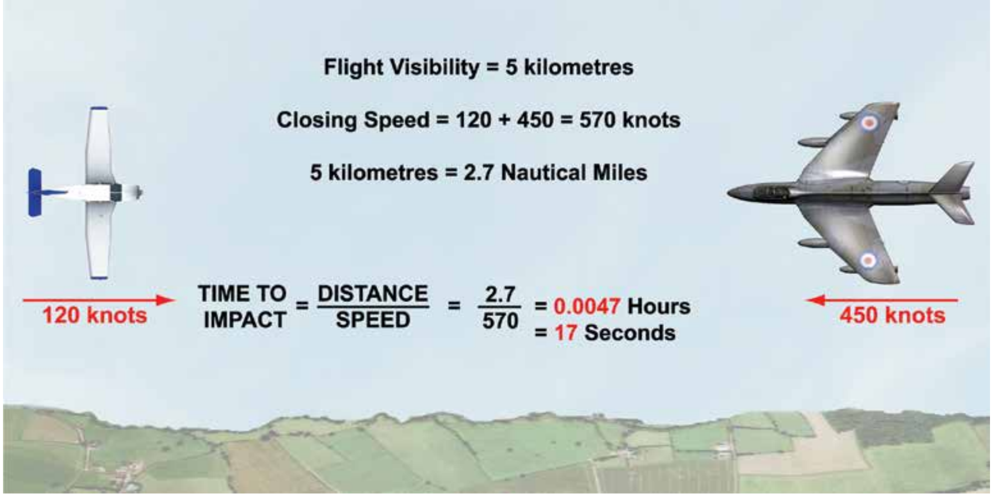

Figure 5.17.

Step One. Calculate closing speed. This would be 120 knots plus 450 knots, giving 570 knots or, otherwise expressed, 570 nautical miles per hour.

Step Two. Convert the 5 kilometres in-flight visibility to nautical miles. This gives us 2.7 nautical miles

Step Three. Enter the figures in the formula to calculate that the time available for reaction is 0.0047 hours, or, just over 17 seconds.

Example 3. *(See Figure 5.18)*
With an in-flight visibility of 3 kilometres, a light aircraft flying at 90 knots sees a fast jet at maximum visual range. The light aircraft pilot assumes that the fast jet is flying at 450 knots. What time would be left to the pilot of either aircraft to take avoiding action?

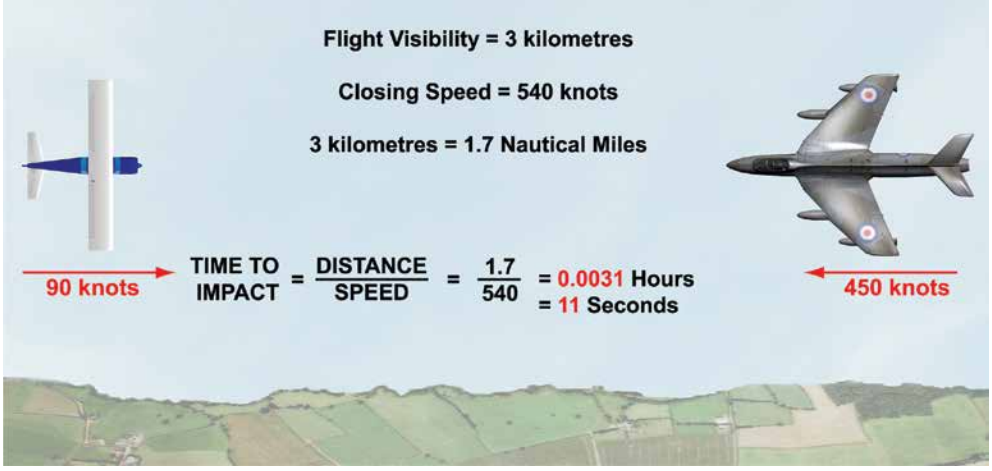

Figure 5.18.

Example 4. *(See Figure 5.19)*
Two light aircraft are on a head-on collision course with a closing speed of 280 knots. Flight visibility is 5 kilometres. What would be the time available to either pilot to take avoiding action, if visual contact were made at maximum visual range?

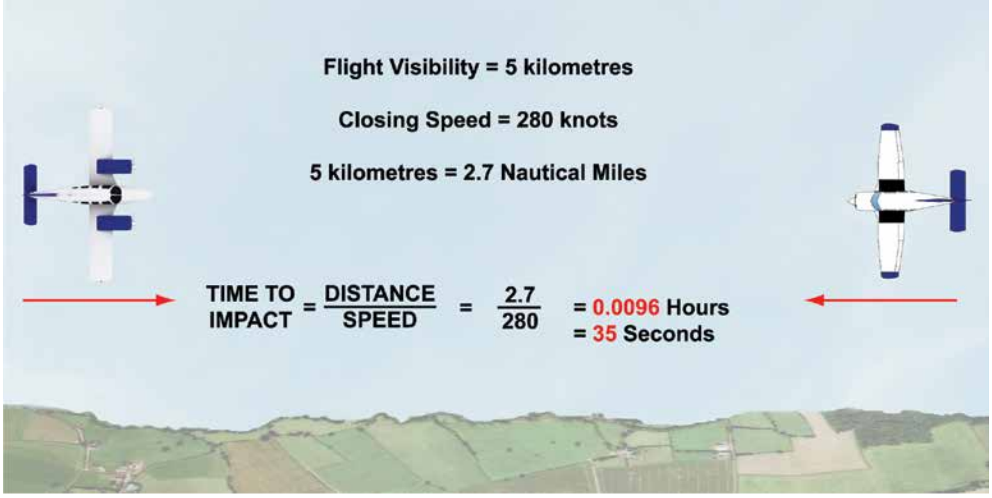

Figure 5.19.

A Point to Ponder.
It is worth noting that for the pilot of an aircraft on a head-on collision course with a fast-moving jet, the image of the approaching jet will remain small, increasing in size only slowly at first, until just before impact when the image would grow in size very rapidly.

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Representative PPL - type questions to test your theoretical knowledge of The Eye.

1. How would a light aircraft pilot perceive the image of a fast moving jet approaching head-on? The image would be:

    a. Small at first and grow in size steadily and regularly
    b. Small at first, displaying an immediate rapid growth rate, but less rapidly just before impact
    c. Small at first, maintaining a constant size and approach rate
    d. Small at first, displaying a slow growth rate, then increasing in size rapidly just before impact

2. The iris is responsible for controlling:

    a. The rate of dark adaption
    b. The amount of light entering the eye
    c. The rate of light adaption
    d. The amount of accommodation

3. In order to see an object best, at night, a pilot should:

    a. Look directly at the object, blinking several times
    b. Look slightly to one side of the object
    c. Look directly and intensely at the object
    d. Look away from the object and then repeatedly look back at it

4. The ability of the lens to change shape to focus an image on the retina is called:

    a. Acuity
    b. Acclimatisation
    c. Accommodation
    d. Auto-kinesis

5. The sensors called ‘Rods’:

    a. Are sensitive to lower light levels than the ‘Cones’
    b. Are used primarily by day
    c. Are highly sensitive to colour changes
    d. Are concentrated on the optic nerve

6. Light levels at high altitude are dangerous because they:

    a. Cause reflections on the windscreen
    b. Contain more of the damaging Blue and UV light
    c. Cause the iris to close, blinding the pilot
    d. Cause a blind spot on the optic nerve

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7. A person who has ‘Myopia’:

   a. Has a shorter than normal eyeball and vision is corrected with a Concave lens
   b. Has a longer than normal eyeball and vision is corrected with a Convex lens
   c. Has a shorter than normal eyeball and vision is corrected with a Convex lens
   d. Has a longer than normal eyeball and vision is corrected with a Concave lens

8. The part of the eye where we have the best visual acuity is:

   a. The fovea
   b. The iris
   c. The pupil
   d. The peripheral retina

9. Astigmatism is the name for:

   a. The ability of the lens to change shape
   b. An eyeball which is too short
   c. A mis-shapen cornea
   d. Colour blindness

10. Two light aircraft are on a head-on collision course with a closing speed of 180 knots and a flight visibility of 3 kilometres. If contact was made at maximum visual range, what time is available for either pilot to take avoiding action?

   a. 27 seconds
   b. 34 seconds
   c. 51 seconds
   d. 1 minute and 30 seconds

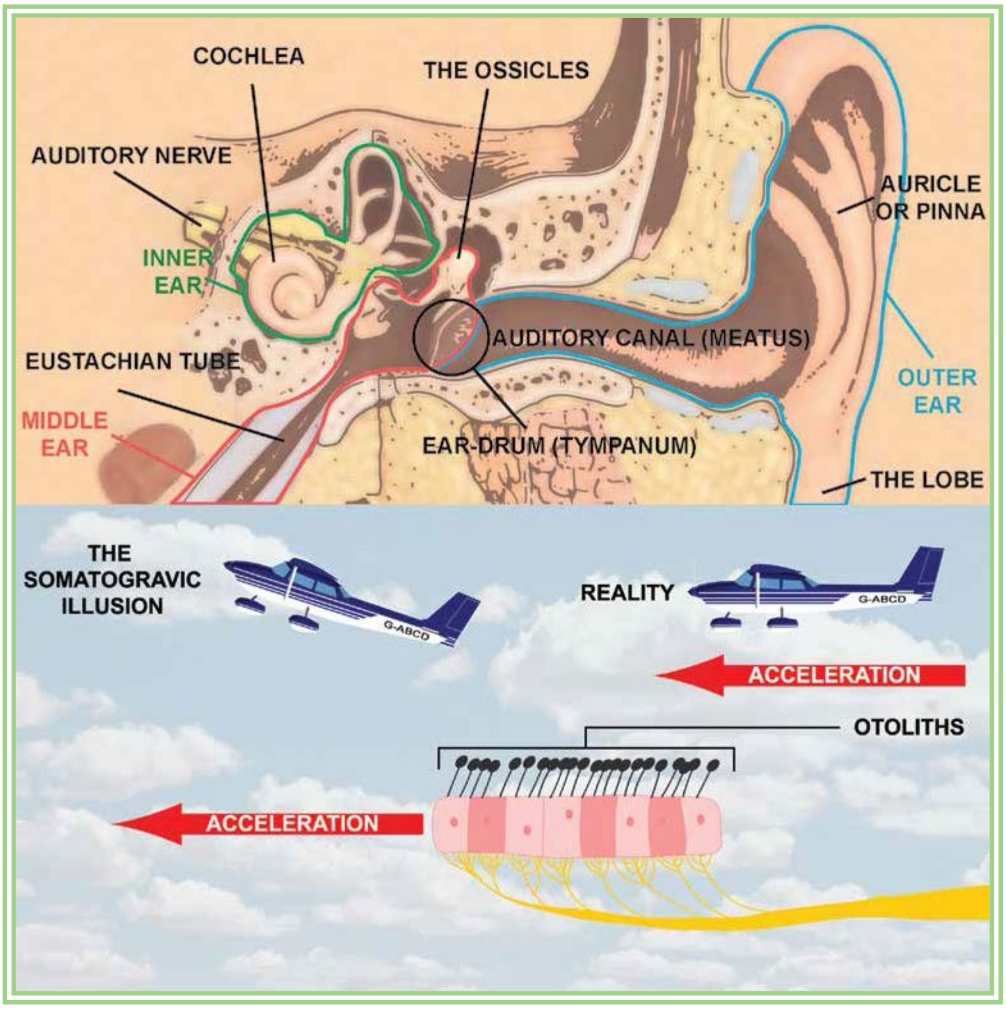
11. The light-sensitive tissue lining the rear of the eyeball which contains rods and cones is know as:

   a. The pupil
   b. The cornea
   c. The retina
   d. The iris

Question	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
Answer											

The answers to these questions can be found at the end of this book.

CHAPTER 6
THE EAR



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FUNCTIONS OF THE EAR.

The ear performs two quite separate functions and provides us with two important senses:

1. Hearing. The outer ear is used as a collector of sound waves from the air which the hearing mechanism then transmits through nerve fibres to the auditory centre of the brain where sound is registered.

2. Balance. The ear acts as a balance organ and acceleration detector. The overall construction of the ear is shown in *Figure 6.1 see below*.

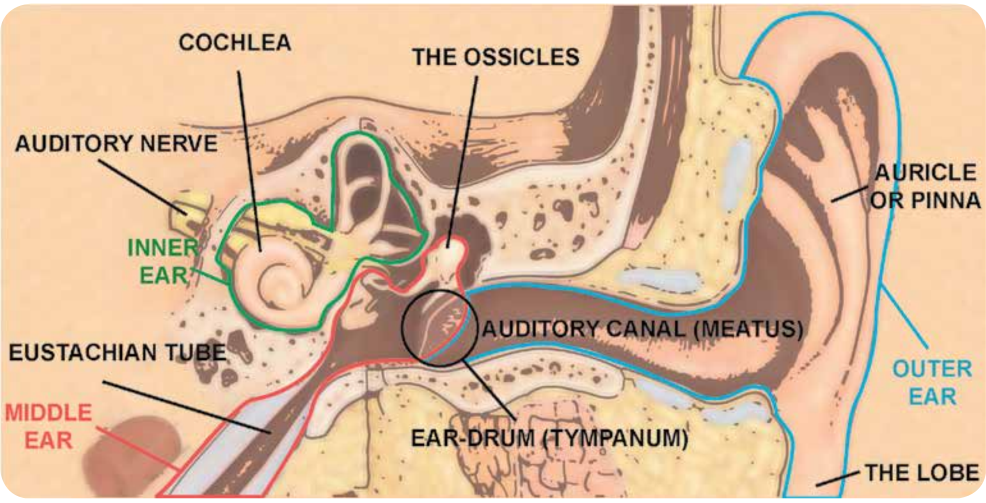

Figure 6.1 Overall Construction of the Ear.

The auricle or pinna comprises the shell-like upper part of the ear and the lobe. Its function is to collect sounds and conduct them to the auditory canal (meatus) and on to the ear-drum. The ear-drum - or Tympanum - separates the outer from the middle ear.

The Middle and Inner Ear.

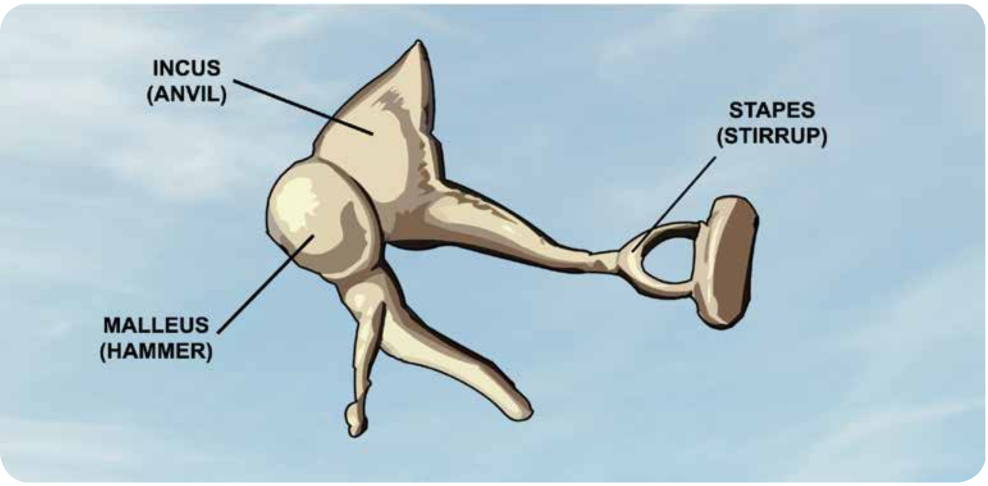

Figure 6.2 The Ossicles (The Middle Ear).

Connected to the ear-drum is a linkage of three small bones; these are the ossicles. *(See Figure 6.2)*.

The ossicles are the three tiny bones in the ear. These are the malleus, incus and stapes.

The ossicles comprise the malleus, or hammer, incus ,or anvil, and stapes, or stirrup bone, which transmit the vibrations across the middle ear to the inner ear whose main components are the cochlea and semi-circular canals *(see Figure 6.3)*. The middle ear is filled with air and the inner ear is filled with liquid.

The last of the bones in the middle ear - the stapes or stirrup bone - is attached to the oval window of the inner ear where a diaphragm sets in motion the fluid of the cochlea. The extent and frequency of vibration of tiny hair-like cells within this fluid are detected by the auditory nerve which leads to the cortex of the brain where sound is perceived.

The Eustachian Tube.

The eustachian tube vents to the mouth and nose allowing pressure in the middle ear to equalise across the ear-drum with outside or ambient pressure, when climbing or descending in flight. Pressure equalisation through the eustachian tube can be hindered by inflammation, catarrh, a blocked nose or sinuses, or any infection of the respiratory tract.

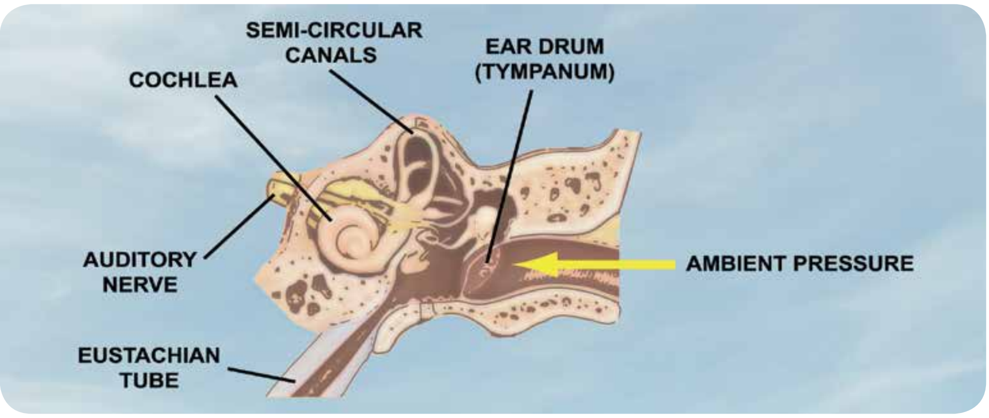

Figure 6.3 The Eustachian Tube and the Inner Ear.

A blocked eustachian tube can cause severe ear pain or even lead to perforation of the ear-drum. Pilots must, therefore, ensure that neither they nor any passengers go flying if the eustachian tube is blocked and the ears cannot be “cleared”.

While an aircraft is climbing, when outside or ambient pressure is decreasing, the higher pressure in the middle ear can normally easily vent to the mouth via the eustachian tube, causing the pilot little problem.

During the descent, however, when ambient air pressure is increasing, a small flap attached to the end of the eustachian tube prevents such easy passage of air back up the eustachian tube to equalise the pressure in the middle ear. It is, therefore, in the descent when the equalising of pressures across the ear-drum is most likely to be experienced.

Do not fly if your eustachian tube is blocked.

In extreme cases, rupture of the ear-drum may occur. This condition is known as Otic Barotrauma. However, normal periodic swallowing movements mean that, in a fit pilot, the condition does not arise. If you experience any problems with pressure equalisation during a descent, swallow deliberately with the nostrils pinched closed; yawn, or blow down the nose, again with the nostrils pinched closed. This is known as the Valsalva Manoeuvre, after Antonio Maria Valsalva (1666 - 1723). Remember, never fly if your eustachian tube becomes swollen or blocked and you cannot clear your ears.

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AUDIBLE RANGE OF THE HUMAN EAR.

Sound is generated by waves or vibrations in the air. Sound has three main qualities:

Pitch, which depends on the frequency of the vibration. The greater the frequency, the higher the pitch or note produced.

Loudness or Intensity, dependent on the amplitude of the vibrations.

Quality, which is a function of various aspects of vibrations, causing either harmonious musical sounds or else discord or noise.

The range of pitch or frequency of sounds that a fit young person can hear lies between 20 and 20 000 Hertz, or cycles per second. However, this detectable sound range also depends on loudness which is measured in decibels.

It is your ability to detect a range of sound frequencies of varying degrees of loudness which is normally tested during your medical examination. Below is a table *(Figure 6.4)* showing typical noise levels in decibels against a corresponding description of sounds that might produce such degrees of loudness.

Sound	**Noise Level (dB)**
Threshold of hearing	0
Rustle of leaves in a gentle breeze	10
Average whisper (at 4 feet)	20
Quiet conversation	30
Office noise	40
Conversation in a noisy factory	50
Loud street noises (trucks etc.)	60
Standing close to heavy machinery	80
Maximum recommended for 8 hours exposure	90
Maximum recommended for 2 hours exposure	100
Maximum recommended for 30 minutes exposure	110
Standing near a piston engine aircraft (noise becoming uncomfortable)	120
Standing near a jet aircraft (threshold of pain)	130

Figure 6.4 Table showing typical noise levels

HEARING IMPAIRMENT.

Any degradation in a human being’s ability to hear clearly is known as “hearing impairment”. There are three categories of hearing impairment:

1. Conductive Deafness.

Conductive Deafness can be caused by a build-up of wax, or damage to the sound-conductivity system: the ossicles or the ear-drum. Damage may be caused by a blow to the ear, or by otic barotrauma.

2. Noise Induced Hearing Loss.

Continued exposure to noise in excess of 90dB may result in Noise Induced Hearing Loss. Ear protection at these levels is essential.

Loud noises can damage the very sensitive membrane in the cochlea, especially the fine structures on this membrane. The loss of hearing may at first be temporary, but continued exposure to loud noise in excess of 90 decibels (db) may result in permanent loss of hearing.

An early symptom of Noise Induced Hearing Loss is an inability to hear high pitched notes as these notes are normally detected by the finer cells which suffer the greatest damage. There is evidence that over-exposure to loud music at discos, and the use of personal stereos, can cause the early onset of hearing impairment in young people.

Environmental noise pollution can be a significant factor in the onset of Noise Induced Hearing Loss. You should always make sure that you protect your hearing whenever environmental noise is excessive. Noise of high frequency is most damaging to the ear.

3. Presbycusis.

A person's hearing deteriorates with advancing age. Once again, it is the high-frequency range of sound which is affected first. This condition is known as Presbycusis.

Hearing impairment can lead to the misinterpretation of radiotelephony transmissions, which, in turn, may possibly cause a Flight Safety hazard. And, of course, any significant deterioration in a pilot's hearing can lead to the loss of one's pilot's licence.

Growing older is unavoidable and accidents may strike even the most prudent amongst us. But we all should plan to protect ourselves from Noise Induced Hearing Loss. Always protect your ears if you know that you are about to be exposed to excessive noise.

Headset-style ear protectors give the best protection, reducing noise by about 40 decibels. Ear plugs can also be used. Ear plugs reduce noise by about 20 decibels.

In the cockpit, use the best quality headset you can afford in order to reduce background noise. When visiting a large airport, avoid standing near a running jet engine if you have no ear-protection.

BALANCE.

As well as distinguishing sound, the ear also provides us with our sense of balance, helping us to orientate ourselves spatially through mechanisms which detect accelerations, both in a straight line and when turning. Note that the term "orientation" refers to a human being's ability to maintain equilibrium and to interpret the body's position in space.

In terms of maintaining spatial orientation, the balance sensors situated in the ear provide us with a secondary system only. Pilots should always remember that the primary and most reliable sense of spatial orientation is eyesight. However, it is extremely important for the pilot to know about the function of the ear's balance sensors so that he can understand how spatial disorientation may occur in flight.

The Vestibular Apparatus, Spatial Orientation and Balance.

Within the ear, the semi-circular canals and the otoliths (fine, sensory hairs ending in miniscule "grains") make up the vestibular apparatus which helps human beings maintain spatial orientation.

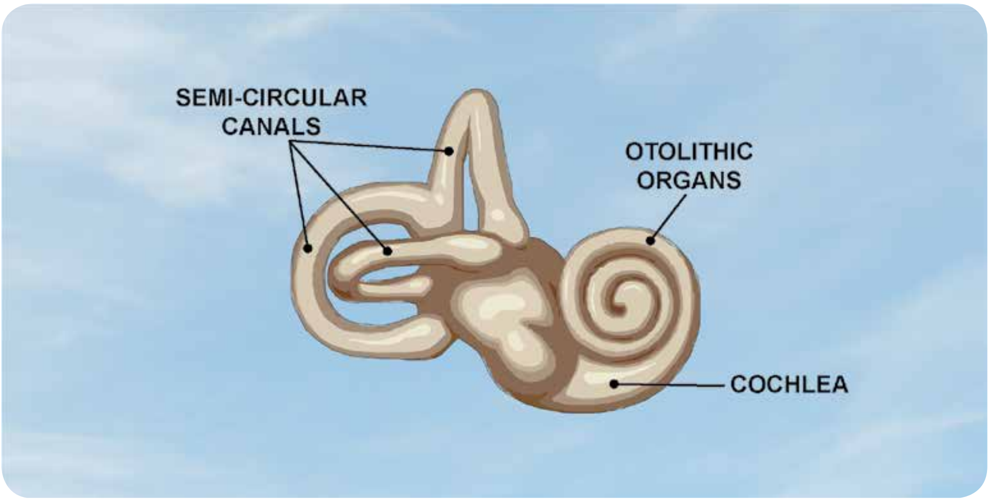

Figure 6.5 The Vestibular Apparatus.

The ***vestibular apparatus*** *contains the semi-cicular canals and otoliths that give us our sense of balance.*

The otoliths are located between the semi-circular canals and the cochlea. The otoliths are not shown in *Figure 6.5*, but are depicted in *Figures 6.11* and *6.12.*

The otoliths detect acceleration in a straight line while the semi-circular canals detect angular acceleration. There are three semi-circular canals oriented at right angles to one another as shown in *Figure 6.5*. The angular accelerations that each semi-circular canal detects are in the sense of pitch, roll and yaw.

We have already said that the word "orientation" refers to a human being's ability to maintain equilibrium and to interpret the body's position in space. Human beings maintain spatial orientation using a combination of three factors:

- Their sense of vision.
- The ear's balancing mechanism.
- The body's ability to detect pressures through nerve receptors, called propriceptors, often known in the flying world as the "seat of the pants" sense.

The system of nerve receptors that give us this "seat of the pants" sense is known as the somatosensory system. Pilots must be very aware that information from their somatosensory system is very unreliable and deceptive. In flight, pilots must maintain spatial orientation using their most reliable sense, vision, either by looking outside the aircraft when flying in Visual Meteorological Conditions, or relying on their flight instruments if no outside visual references are present.

Pilots must also be aware that their ear's balancing mechanism, that is their vestibular apparatus, is not sufficiently reliable for them to maintain spatial orientation using this sense alone. We will now, therefore, look briefly at how the vestibular apparatus works and at the problems of balance and disorientation that may arise in flight.

As we have noted, the otoliths detect linear accelerations and the semi-circular canals detect angular accelerations. Note that they detect accelerations or changes in velocity only, and not constant linear velocity. Therefore, in the absence of any visual signals, the ear's balance sensors alone will not differentiate between a state of rest and flying at a constant speed, nor will they differentiate between a steady balanced turn and flying wings level. In other words, our balance organs can detect accelerations but cannot determine what position we are in if no acceleration is present. This is a most vital point that pilots must understand and is the reason why pilots must always rely on their eyes and/or flight instruments. Relying on the vestibular apparatus alone often leads to disorientation.

Both the otolith organs and the semi-circular canals send signals to the brain by means of impulses arising from the body being subjected to accelerations. To illustrate this, we will look at fluid accelerations in the semi-circular canals. Remember, here, we are dealing with principles only. We give no neuro-biological details of the operation of the vestibular apparatus.

The Semi-Circular Canals.

The **semi-circular canals** contain fluid which can flow freely through the canal. Fluid flow occurs when the body or head is subject to angular acceleration. The flow takes place in the opposite direction to the acceleration, the fluid lagging behind the displacement. There is no fluid flow when the body is at rest or if linear and turning movement is taking place at a steady speed.

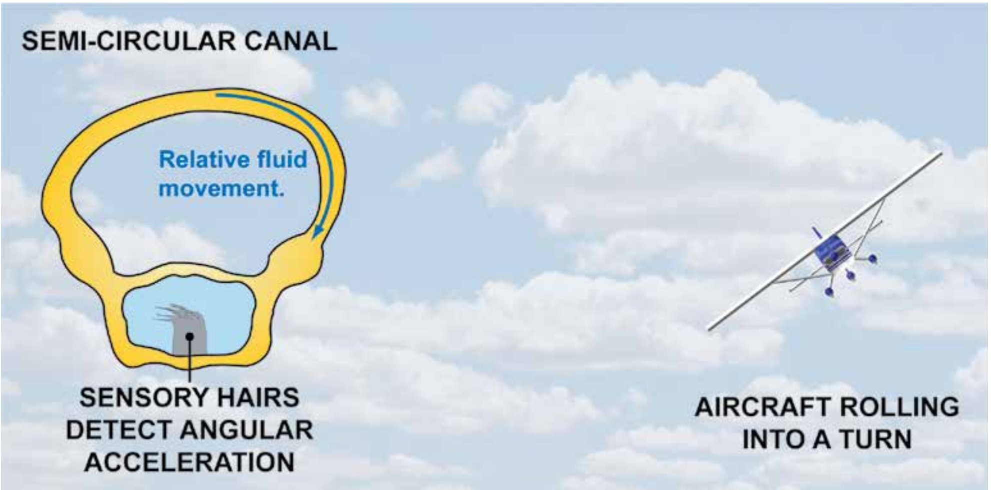

Figure 6.6 One of the Semi-Circular Canals Detecting Angular Acceleration.

When the fluid moves, sensory hairs contained within a gelatinous material will move with the fluid, in the same direction. Nerve cells within the hairs convert this movement into electric signals which are then conveyed to the brain. This is how a human being perceives movement.

When the angular acceleration ceases, fluid flow also ceases and the sensory hairs are no longer displaced. The brain, therefore, no longer detects any motion. No motion will be detected when the body is upright and motionless, upright and travelling at a steady speed, or inclined at an angle in a steady turn, at constant angular velocity.

The brain, therefore, when receiving information from the vestibular apparatus only, is unable to sense whether the body is upright or in a steady, balanced turn. Only information from the eyes and instruments can tell a pilot he is in steady level flight or in a steady, balanced turn. Let us now look at the various sensations that a pilot needs to understand to help him maintain his spatial orientation.

SENSORY DISORIENTATION - ANGULAR ACCELERATIONS.

The sensation experienced when the vestibular apparatus of the ear leads to a pilot making an incorrect assessment of attitude on entering, maintaining or exiting turns, is known as the **leans**. There are two common circumstances under which the leans may be experienced.

Case One. The first of these is when, from straight and level flight, the pilot commences a very gentle roll to enter a turn; so gentle that the movement of the liquid in the semi-circular canals is not sufficiently pronounced to cause a detectable bending of the hair cells (see *Figure 6.7*, below - Note that, in all 4 diagrams, the aircraft is depicted flying "out of the page", towards the reader).

The Leans arise from incorrect perception of attitude associated with turning.

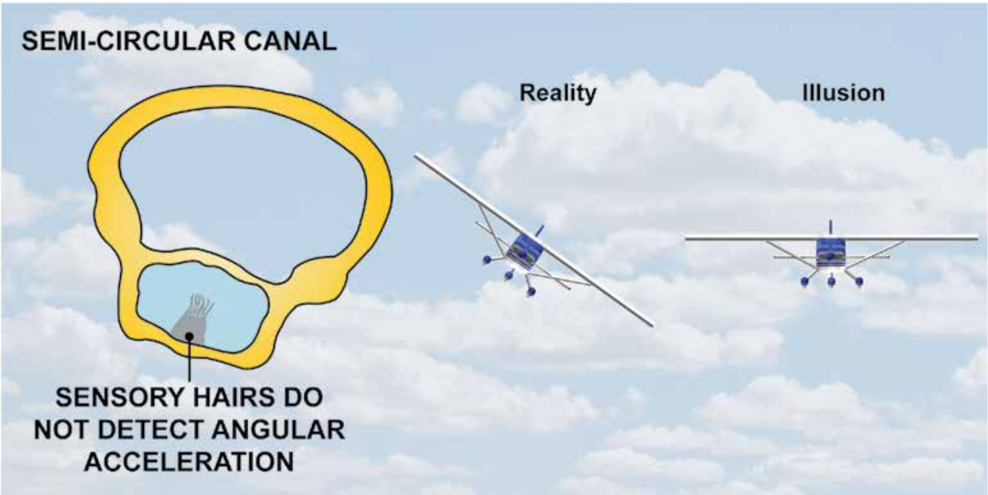

Figure 6.7 Disorientation During a Gentle Roll to Enter a Turn to the Left.

We see that, although the pilot has rolled gently into a turn to the left, the ear's balance mechanism senses no change in orientation. Consequently, the pilot may still believe himself to be flying straight and level.

Now, if the subsequent corrective roll to the right, to regain level flight, is made sharply, this acceleration <u>will</u> be detected by the ear's balance mechanism *(see Figure 6.8)*. So, even though the aircraft is now, in reality, straight and level, a pilot feels that he has entered a turn to the right.

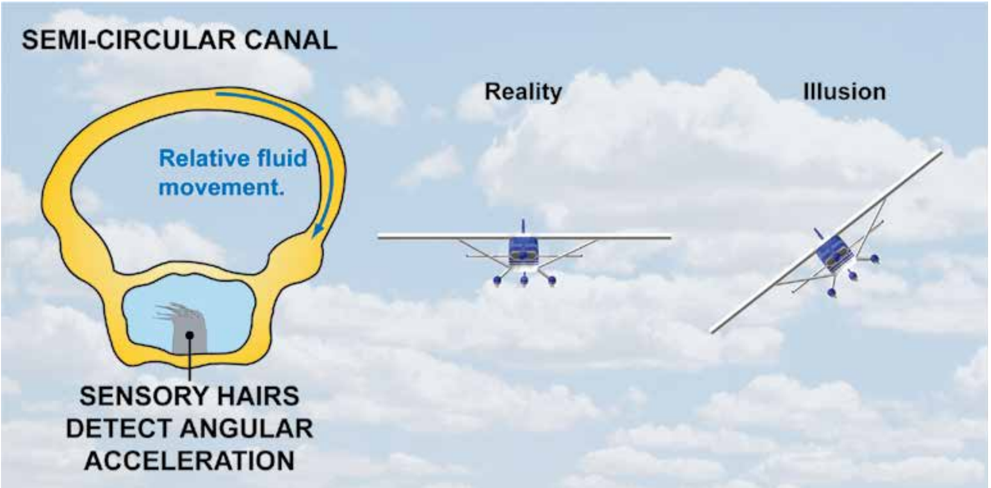

Figure 6.8.

Case Two. In the second case, we are assuming that the pilot has, for some time, been carrying out a steady turn to the right. Because the turn is steady and balanced, there is no movement of fluid in the semi-circular canals and the hairs have erected themselves. This gives the pilot who lacks visual information the erroneous feeling that he is straight and level *(see Figure 6.9, below)*.

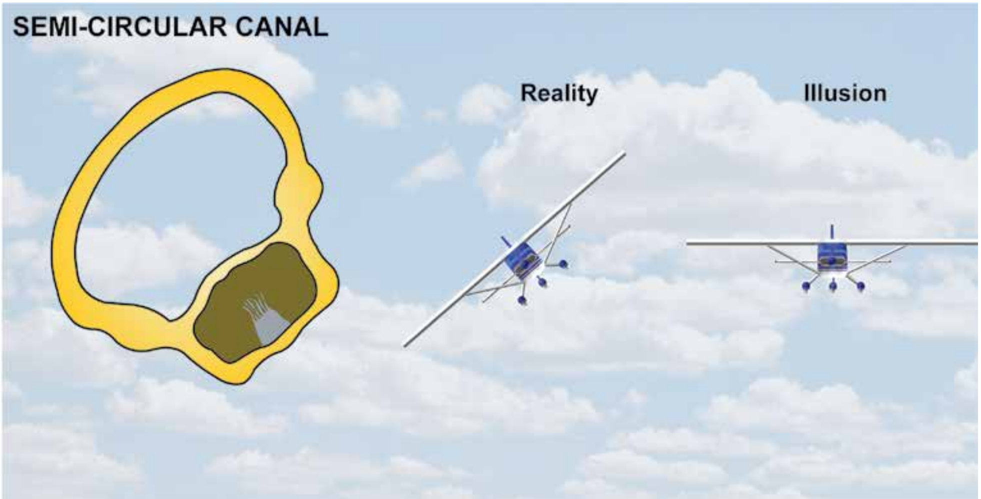

Figure 6.9.

As the pilot exits the turn by rolling to the left to regain straight and level flight, the fluid and the hairs move, giving a false impression of entering a turn to the left when, in fact, the wings are level.

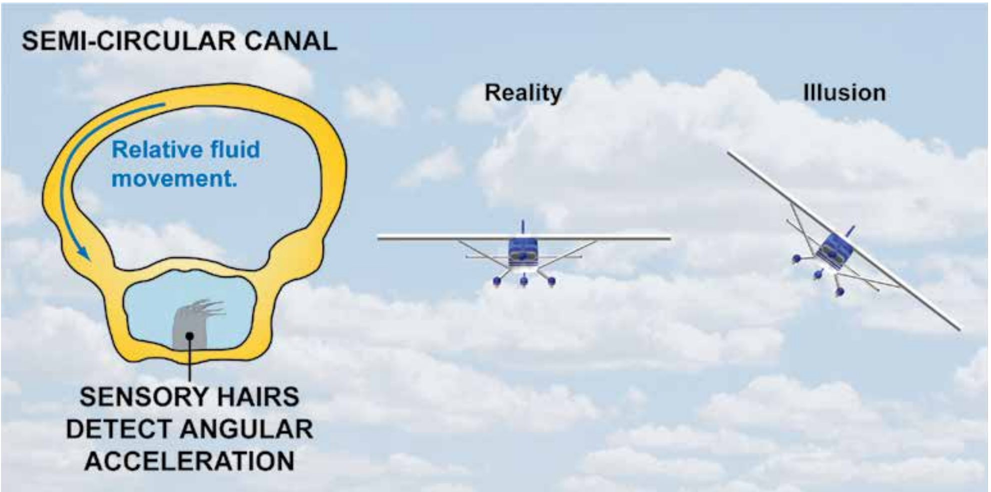

Figure 6.10.

In Case One and Case Two, the pilot will be subjected to two conflicting signals. His visual sense will tell him one thing, whereas his vestibular apparatus will tell him another. This conflict between vestibular apparatus and visual sensory inputs is the primary cause of spatial disorientation, and indeed, of motion sickness. Of course, for a healthy, fully-trained pilot, the visual signals will dominate and he is hardly likely to become disorientated. But a passenger or new student pilot may experience spatial disorientation.

If a pilot becomes aware that he is spatially disorientated, he must look out at the visual horizon if in VMC, or, if in IMC, trust his instruments.

As a pilot, you must remember to respect, at all times, the cardinal rule that if you suspect you are suffering from disorientation, you must concentrate on and believe the aircraft's instruments, or the external horizon.

The rule for maintaining spatial orientation is:

IF IN VISUAL METEOROLGICAL CONDITIONS: LOOK OUT AT THE HORIZON. IF IN INSTRUMENT METEOROLOGICAL CONDITIONS: BELIEVE YOUR INSTRUMENTS.

SENSORY DISORIENTATION - LINEAR ACCELERATION.

In level flight, a pronounced acceleration in a straight line will cause the hair sensors in the otoliths to move backwards. This sends a signal to the brain indicating, falsely, that the head is tilting backwards, giving the pilot the false impression that the nose of the aircraft is pitching up (*see Figure 6.11*).

Linear acceleration may be perceived as a false pitch-up sensation.

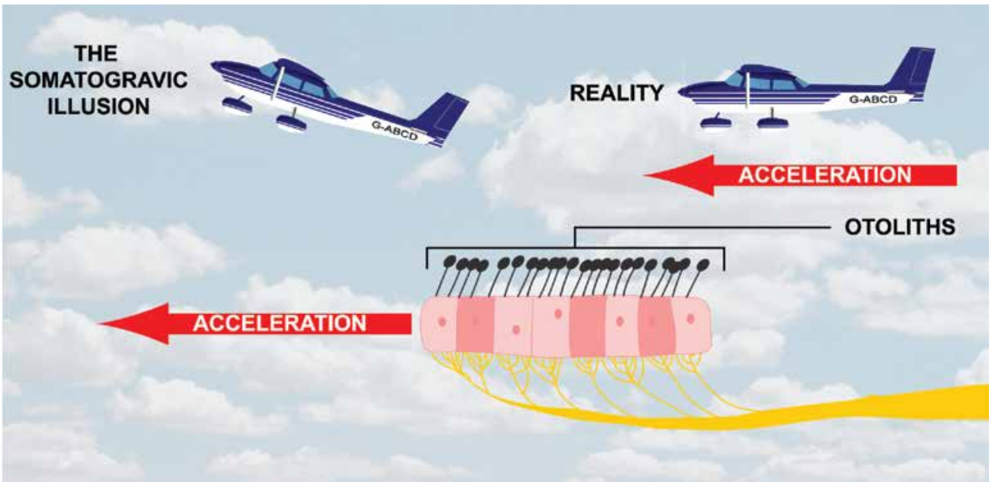

Figure 6.11 Somatogravic Illusion - Acceleration.

There is a danger that a pilot may believe this input from the otoliths and that he may, consequently, push the control column forward, putting the aircraft into a dive. (You may have noticed that pilots of carrier-borne aircraft, during launch, invariably put their hands on the overhead console so as not to be confused by this illusion. They take control of the column after the initial acceleration from the deck).

Linear deceleration may be perceived as a false pitch-down sensation.

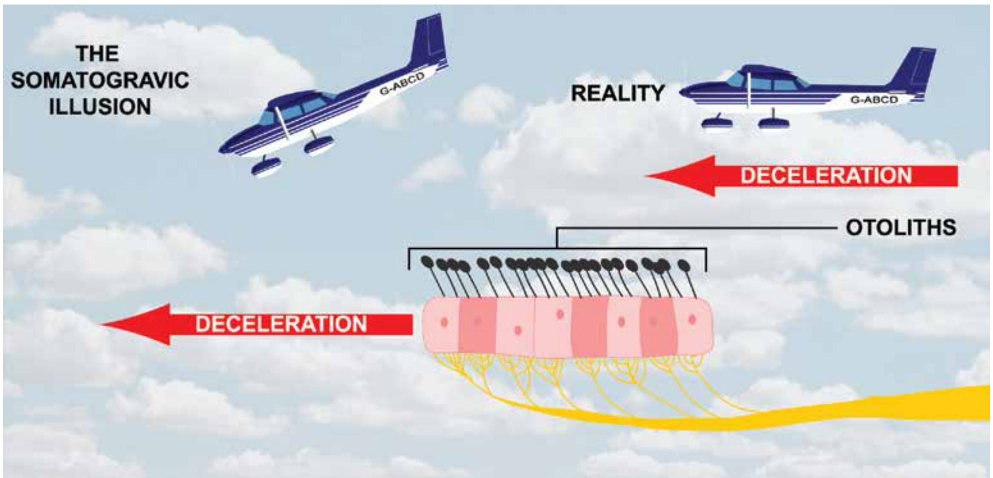

Figure 6.12 Somatogravic Illusion - Deceleration.

Conversely, a sharp linear deceleration gives the impression that the nose of the aircraft is pitching down *(see Figure 6.12)*. This may cause the pilot to pull the control column rearwards and subsequently stall the aircraft. These illusions are known as somatogravic illusions. In light aircraft, somatogravic illusions are mild.

MOTION SICKNESS.

Motion sickness arises when a human being is exposed to real or apparent motion of an unfamiliar kind. Motion sickness is caused by a conflict between the visual and vestibular apparatus signals.

The symptoms of motion sickness are:

- Nausea.
- Hyperventilation.
- Vomiting.
- Pallor.
- Cold sweating.
- Headache.
- Depression.

Motion Sickness results from a conflict between visual signals and vestibular apparatus signals.

In non-aerobatic light-aircraft flying, it should be rare for a pilot to suffer from motion sickness. However, a passenger who has little experience of flying may well experience motion sickness symptoms. If this should be the case with one of your passengers, you should:

- Advise him to keep the head upright and still, if possible using the eyes to orientate himself.
- Open the cockpit ventilators to increase the flow of fresh air.
- Use smooth and coordinated control movements and avoid manoeuvres which generate pronounced positive or negative g forces.

Representative PPL - type questions to test your theoretical knowledge of The Ear.

1. The three parts of the ear are the:

   a. Incus, malleus and stapes
   b. Outer, middle and inner
   c. Cochlea, otoliths and tympanum
   d. Ear lobe, ear canal and ear drum

2. The bones in the middle ear are known collectively as:

   a. The otoliths
   b. The monoliths
   c. The ossicles
   d. The saccules

3. A fit young person can detect a range of sounds between:

   a. 20 and 20 000 Hertz
   b. 500 and 3 000 Hertz
   c. 700 and 5 000 Hertz
   d. 50 and 10 000 Hertz

4. The function of the eustachian tube is to:

   a. Equalise pressure between the middle and inner ear
   b. Connect the inner ear to the back of the throat
   c. Allow circulation of fluid in the semi-circular canals
   d. Equalise pressure between the outer and middle ear

5. Permanent hearing loss may result from continuous exposure to:

   a. Noise in excess of 120 decibels
   b. Dusty conditions, allowing a build-up in ear wax
   c. Noise in excess of 90 decibels
   d. Excessive heat which boils the fluid in the semi-circular canals

6. Permanent deafness that is associated with old age, is known as:

   a. Myopia
   b. Presbyopia
   c. Mycusis
   d. Presbycusis

7. The main function of the vestibular apparatus is to:

   a. Detect angular and linear accelerations
   b. Mechanically transmit sound to the cochlea
   c. Prevent excessive sounds from damaging the ear drum
   d. Prevent excessive sounds from damaging the otoliths

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8. To maintain spatial orientation in the absence of visual references, the pilot should:

   a. Believe the sensations of his vestibular apparatus
   b. Immediately climb to get above cloud
   c. Believe the "seat of the pants" sensations from the somatosensory system
   d. Believe the aircraft instruments

9. Motion sickness arises when there is:

   a. Vertical displacement from the horizontal axis
   b. Disorientation caused by loss of visual references
   c. A mismatch between visual and vestibular signals
   d. Vertical displacement from the longitudinal axis

10. Which of the conditions given below, are symptomatic of motion sickness:

    (i) Nausea
    (ii) Hypoxia
    (iii) Hyperventilation
    (iv) Pallor
    (v) Stomach cramp
    (vi) Cold sweating

    a. i, ii, iii and iv
    b. iii only
    c. i, iii, iv and vi
    d. i, iii, v and vi

11. What is the cause of conductive deafness?

    a. Damage to the Pinna
    b. Blockage of the Eustachian Tube
    c. Damage to the Ossicles and/or the Ear-Drum
    d. Low ambient pressure

12. Which part of the ear senses linear accelerations?

    a. The Ossicles
    b. The Eustachian Tube
    c. The Auditory Nerve
    d. The Otoliths in the Vestibular Apparatus

Question	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
Answer											

Question	**12**
Answer	

The answers to these questions can be found at the end of this book.

CHAPTER 7

FLYING AND HEALTH

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INTRODUCTION.

Military pilots and airline pilots have to pass regular and stringent medical examinations in order to train for and pursue their careers. Candidates for professional pilot training may fail the initial medical selection because of quite minor defects of vision, respiration, the cardio-vascular system, and so on. Thankfully, those wishing to fly as private pilots are not subject to the same, severe medical regulations as their professional colleagues. Nevertheless, a medical examination does have to be passed and, perhaps more importantly, private pilots, whether under training or qualified, must be capable of positively assessing their own fitness to fly before every single flight.

We learned that, when flying, our bodies are exposed to a potentially more hostile environment than on the ground. At high altitudes, the amount of Oxygen in the air we breathe will be less than at sea-level, and the air pressure lower. Certain aircraft manoeuvres will increase the gravitational acceleration to which our body is subjected. Furthermore, in certain flight conditions, work-loads will be high and demands on our decision-making ability may be severe.

You will readily appreciate, therefore, that in order to operate competently and safely in such conditions, a high level of general fitness is required. Consequently, as a pilot, you must be able to assess your day-to-day state of health accurately in order to decide whether or not you are fit to carry out each flight that you undertake.

Remember also that you have a responsibility not only towards yourself but also towards your passengers, other users of the air, and to the general public living and working beneath your flight path.

MEDICAL REQUIREMENTS FOR THE PRIVATE PILOT'S LICENCE.

PPL applicants for a pilot's licence must be declared medically fit by an appropriate medical authority.

As the holder of a JAR-FCL PPL, you may fly aircraft for which you have a type or class rating in any JAA member state. Consequently, medical regulations are rather formal. An applicant for a JAR-FCL PPL must hold a valid JAR-FCL Class One or Class Two Medical Certificate. A pilot who wishes to apply for a JAR-FCL PPL only, should arrange for a "Class 2" medical examination. In the United Kingdom, the medical examination must be undertaken by a CAA Authorised Medical Examiner. Full details of the medical requirements for the JAR-FCL PPL can be found on the UK Civil Aviation Authority's (CAA) website.

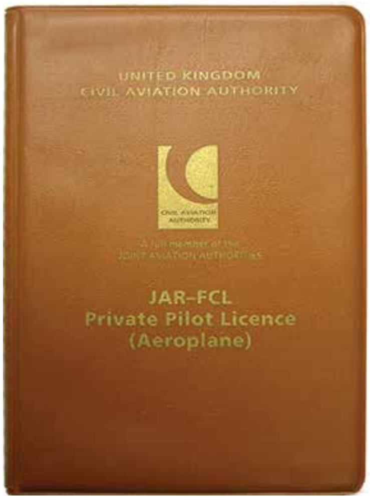
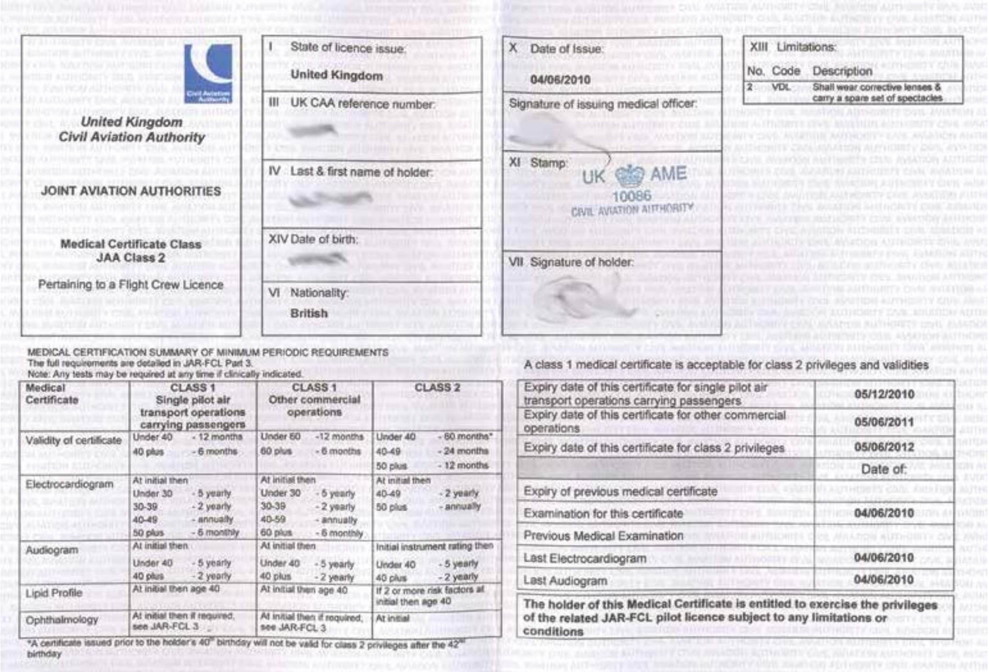


Figure 7.1 Private Pilot's Licence.

In June 2010, the URL of the UK CAA's relevant web page was **http://www.caa.co.uk/default.aspx?catid=49** This URL may change so if it does not lead you to the information required, go to the UK CAA's Home Page or contact the UK CAA's Flight Crew Licensing Department by telephone or post.



United Kingdom
Civil Aviation Authority

JOINT AVIATION AUTHORITIES

Medical Certificate Class
JAA Class 2

Pertaining to a Flight Crew Licence

I State of licence issue:
United Kingdom

III UK CAA reference number:
[redacted]

IV Last & first name of holder:
[redacted]

XIV Date of birth:
[redacted]

VI Nationality:
British

X Date of Issue:
04/06/2010

Signature of issuing medical officer:

XI Stamp:
UK AME
10086
CIVIL AVIATION AUTHORITY

VII Signature of holder:

XIII Limitations:

No.	Code	Description
2	VDL	Shall wear corrective lenses & carry a spare set of spectacles

MEDICAL CERTIFICATION SUMMARY OF MINIMUM PERIODIC REQUIREMENTS
The full requirements are detailed in JAR-FCL Part 3.
Note: Any tests may be required at any time if clinically indicated.

Medical Certificate	CLASS 1 Single pilot air transport operations carrying passengers	CLASS 1 Other commercial operations	CLASS 2
Validity of certificate	Under 40 - 12 months 40 plus - 6 months	Under 60 -12 months 60 plus - 6 months	Under 40 - 60 months* 40-49 - 24 months 50 plus - 12 months
Electrocardiogram	At initial then Under 30 - 5 yearly 30-39 - 2 yearly 40-49 - annually 50 plus - 6 monthly	At initial then Under 30 - 5 yearly 30-39 - 2 yearly 40-59 - annually 60 plus - 6 monthly	At initial then 40-49 - 2 yearly 50 plus - annually
Audiogram	At initial then Under 40 - 5 yearly 40 plus - 2 yearly	At initial then Under 40 - 5 yearly 40 plus - 2 yearly	Initial instrument rating then Under 40 - 5 yearly 40 plus - 2 yearly
Lipid Profile	At initial then age 40	At initial then age 40	If 2 or more risk factors at initial then age 40
Ophthalmology	At initial then if required, see JAR-FCL 3	At initial then if required, see JAR-FCL 3	At initial

*A certificate issued prior to the holder's 40th birthday will not be valid for class 2 privileges after the 42nd birthday

A class 1 medical certificate is acceptable for class 2 privileges and validities

Expiry date of this certificate for single pilot air transport operations carrying passengers	**05/12/2010**
Expiry date of this certificate for other commercial operations	**05/06/2011**
Expiry date of this certificate for class 2 privileges	**05/06/2012**
	Date of:
Expiry of previous medical certificate	
Examination for this certificate	**04/06/2010**
Previous Medical Examination	
Last Electrocardiogram	**04/06/2010**
Last Audiogram	**04/06/2010**

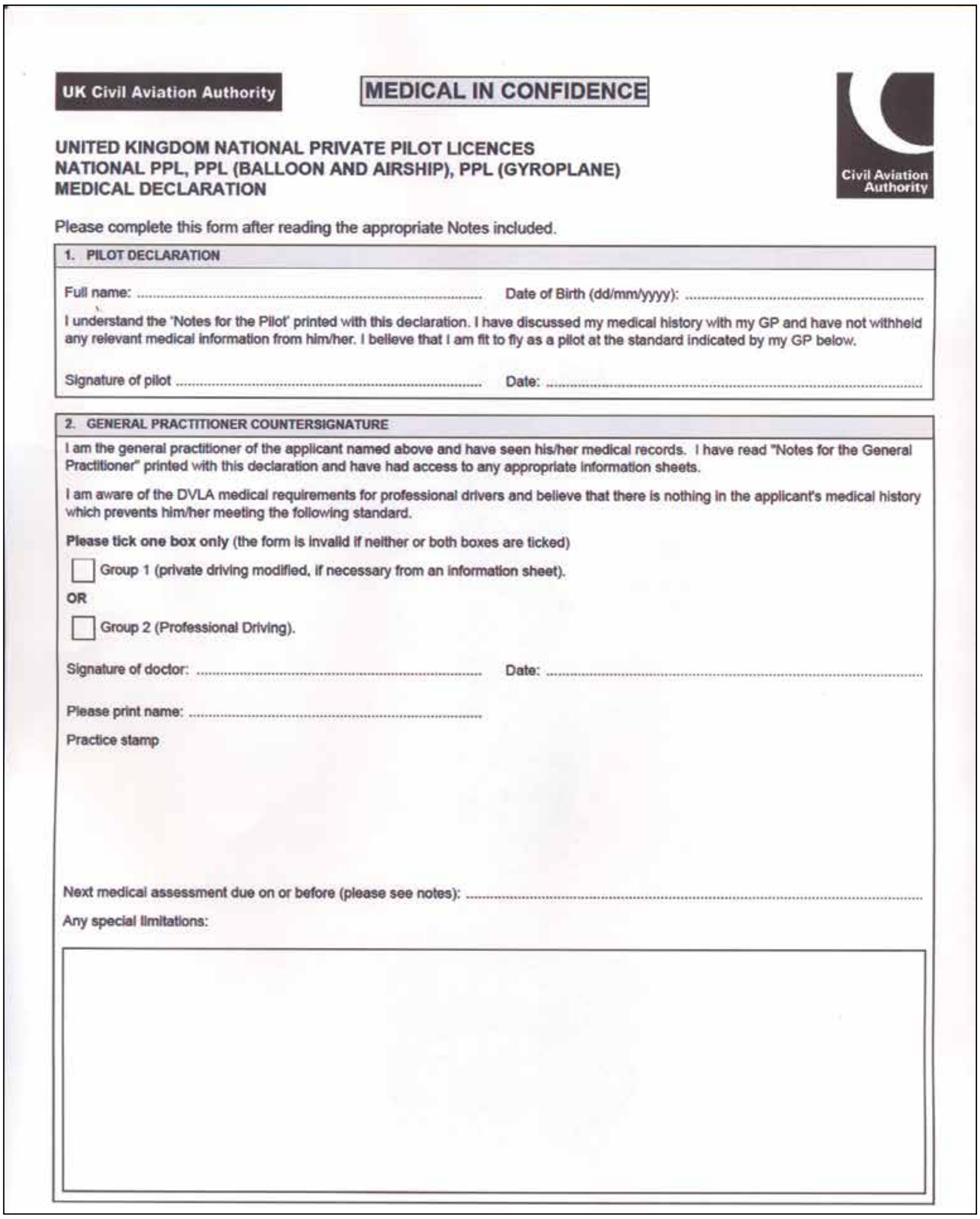
The holder of this Medical Certificate is entitled to exercise the privileges of the related JAR-FCL pilot licence subject to any limitations or conditions

Figure 7.2 Private Pilot's Medical Certificate.

If you wish to obtain a United Kingdom National Private Pilot's Licence (UK NPPL) instead of the JAA PPL, the medical requirements are less stringent. Full details can be found on the UK NPPL web-site: **www.nppl.uk.com**. As far as the medical examination, itself, is concerned, current regulations stipulate that, instead of having to undergo an aviation medical examination conducted by a UK CAA Authorised Medical Examiner, a declaration of medical fitness may be made by the pilot himself. The individual pilot's declaration then has to be validated by a doctor, normally a General Practitioner, who has access to the pilot's medical records. A blank "Declaration of Medical Fitness" is depicted in *Figure 7.3*. Full details of the UK NPPL medical regulations are available on the UK CAA website.

MAINTAINING FITNESS.

Once you have been declared medically fit to fly, you will need to maintain the level of fitness required to be a safe and competent pilot. Certainly, if you wish to make the most of your flying and to extend your piloting skills and qualifications, maintaining a high level of personal fitness is essential. For a person who does not suffer from any medical disorder, the main considerations for keeping fit and well are to follow a healthy diet, exercise regularly, maintain a high standard of personal hygiene and refrain from excess in terms of alcohol consumption and stressful activity. All these considerations may be lumped together under the term **lifestyle**. To remain fit and well, a pilot must maintain positive control of his lifestyle. Special consideration should be given to any form of self-medication, as medications may contain substances which can severely affect a pilot's performance in the air.



UK Civil Aviation Authority

MEDICAL IN CONFIDENCE

Civil Aviation Authority

UNITED KINGDOM NATIONAL PRIVATE PILOT LICENCES
NATIONAL PPL, PPL (BALLOON AND AIRSHIP), PPL (GYROPLANE)
MEDICAL DECLARATION

Please complete this form after reading the appropriate Notes included.

1. PILOT DECLARATION

Full name: .... Date of Birth (dd/mm/yyyy): ....

I understand the 'Notes for the Pilot' printed with this declaration. I have discussed my medical history with my GP and have not withheld any relevant medical information from him/her. I believe that I am fit to fly as a pilot at the standard indicated by my GP below.

Signature of pilot .... Date: ....

2. GENERAL PRACTITIONER COUNTERSIGNATURE

I am the general practitioner of the applicant named above and have seen his/her medical records. I have read "Notes for the General Practitioner" printed with this declaration and have had access to any appropriate information sheets.

I am aware of the DVLA medical requirements for professional drivers and believe that there is nothing in the applicant's medical history which prevents him/her meeting the following standard.

Please tick one box only (the form is invalid if neither or both boxes are ticked)

☐ Group 1 (private driving modified, if necessary from an information sheet).

OR

☐ Group 2 (Professional Driving).

Signature of doctor: .... Date: ....

Please print name: ....

Practice stamp

Next medical assessment due on or before (please see notes): ....

Any special limitations:

Figure 7.3 Pilot's Self Declaration Medical Form.

BODY MASS INDEX (BMI).

Body Mass Index is found by dividing a person's weight in kilograms by the square of his height in metres.

A good indication that a person is following a healthy lifestyle is that his Body Mass Index should lie within prescribed limits. A person's Body Mass Index, or BMI, is simply a measure of a person's weight in relation to his height. The BMI is obtained by dividing weight in kilograms by the square of the height in metres. The BMI is expressed as a coefficient; that is, a number without units.

$$\text{Body Mass Index} = \frac{\text{weight (kg)}}{(\text{height(m)})^2}$$

- For men, a normal BMI lies between 20 and 25.
- A normal BMI for a woman is from 19 to 24.

A BMI above or below these values indicates that a person is overweight or underweight respectively. For example, a man who is 1.80 metres tall and weighs 85 kilograms has a BMI of 26.23 indicating that he is overweight. A BMI of over 30 for a man, or over 29 for a woman, is an indication of obesity. As most of us are aware, being overweight or obese is a common health problem in modern western society.

Keeping an eye on your Body Mass Index is one way of monitoring whether you are of a healthy weight. If you are not, then you may wish to consult a medical practitioner about the best way of controlling your weight. Of course, obvious solutions are to eat less whilst maintaining a balanced and healthy diet, and to exercise.

However, be aware that pilots should not try to lose weight by taking appetite-suppressants, unless under the direct supervision of an Aviation Medical Specialist.

DANGERS OF EXCESSIVE BODY WEIGHT.

Being seriously overweight has obvious disadvantages for a pilot. In addition to problems associated with mobility restriction, cockpit accommodation and, possibly, exceeding the all-up weight for your aircraft, being badly overweight increases a pilot’s susceptibility to the following conditions:

- Heart attack.
- Hypertension.
- Hypoxia at lower altitudes than normal.
- General circulation problems.
- Gout.
- Osteoarthritis.
- Diabetes.
- The inability to tolerate g forces.
- Problems with joints and limbs.
- Decompression Sickness.
- Heavy sweating.
- Chest infections.
- Varicose veins.

Of course, quite apart from the danger to a pilot’s health, all the above conditions adversely affect the quality of a person’s normal day-to-day life, too.

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EXERCISE.

Exercise should be a part of everyone's life who is serious about keeping fit. Exercise promotes both mental and physical fitness, and a sense of well-being. Those who take regular exercise can cope with fatigue much better, and their resistance to stress is improved. Pilots are required to sit for long periods, and, so, regular exercise is of particular importance.

Effective exercise involves doubling the heart rate for 20 minutes, 3 times a week.

To be effective, exercise must be regular, be of sufficient intensity to double the resting pulse rate for at least 20 minutes and be practised, at least, three times per week. Pilots should seek professional advice on exercise regimes to suit their own circumstances.

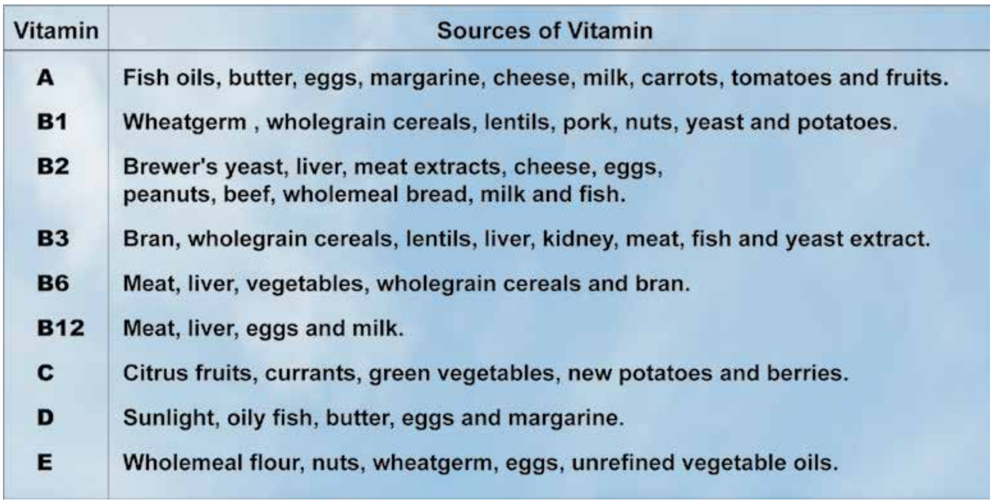
NUTRITION AND FOOD HYGIENE.

A balanced diet is another foundation of good health. A high carbohydrate/fibre and low-fat diet can reduce the risk of coronary heart disease, stroke, diabetes and certain forms of cancer. Sources of carbohydrates include grains, vegetables, nuts, potatoes and fruits. This type of food should make up more than 50% of the calories consumed. The rest should come from lean meats and poultry, fish and low-fat dairy products.

Many nutritionists advise never to miss breakfast and regard breakfast as the most important meal of the day. Medical authorities state that breakfast should supply about 25% of the daily calorie intake. A good breakfast is a must before spending a day at the airfield. A pilot should not embark on a demanding flying sortie on an empty stomach.

Vitamins.

Vitamins are organic food substances found only in living things. With few exceptions, the body cannot manufacture or synthesize vitamins. Vitamins must be supplied in the diet, or in dietary supplements. Vitamins are essential to the normal functioning of our bodies. They help regulate metabolism, help convert fat and carbohydrates into energy, and assist in forming bone and tissue.



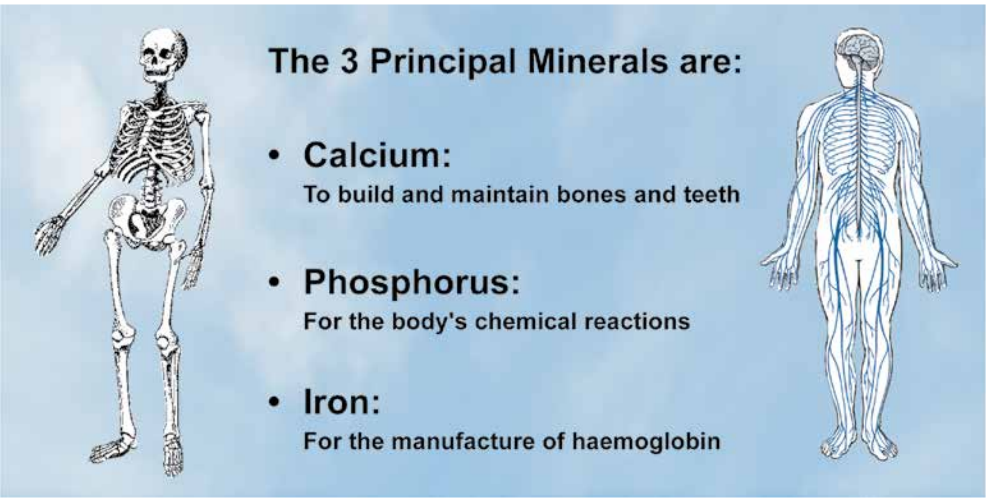
Vitamin	Sources of Vitamin
A	Fish oils, butter, eggs, margarine, cheese, milk, carrots, tomatoes and fruits.
B1	Wheatgerm , wholegrain cereals, lentils, pork, nuts, yeast and potatoes.
B2	Brewer's yeast, liver, meat extracts, cheese, eggs, peanuts, beef, wholemeal bread, milk and fish.
B3	Bran, wholegrain cereals, lentils, liver, kidney, meat, fish and yeast extract.
B6	Meat, liver, vegetables, wholegrain cereals and bran.
B12	Meat, liver, eggs and milk.
C	Citrus fruits, currants, green vegetables, new potatoes and berries.
D	Sunlight, oily fish, butter, eggs and margarine.
E	Wholemeal flour, nuts, wheatgerm, eggs, unrefined vegetable oils.

Figure 7.4 Vitamin Sources.

It is beyond the scope of this book to teach the main benefit to be derived from the different kinds of vitamin. It is sufficient here to note that we can get the vitamins we need by eating a balanced diet. The major sources of vitamins are shown in *Figure 7.4,* on the previous page.

Principal Minerals.

Minerals are also very important, because our bodies need them to grow, develop, and be healthy. Minerals are essential to many vital body processes, from building strong bones to transmitting nerve impulses.



The 3 Principal Minerals are:

- **Calcium:**
  To build and maintain bones and teeth
- **Phosphorus:**
  For the body's chemical reactions
- **Iron:**
  For the manufacture of haemoglobin

Figure 7.5 Principal Minerals.

The three principal minerals which are critical to the body's functions are Calcium, Phosphorus and Iron.

Calcium is the most abundant mineral in the body. It helps with the building and maintaining of bones and teeth. Its sources are milk, milk products, dark green leafy vegetables and shellfish.

Phosphorus, the second most abundant mineral, performs more functions than any other mineral and plays a part in nearly every chemical reaction in the body. The sources of Phosphorus are: grains, cheese and milk, nuts, meats, poultry, fish, dried peas, beans and egg yolks.

Iron is necessary for the manufacture of haemoglobin. Its sources are meats, beans, green leafy vegetables, grain products, nuts and shellfish.

Contaminated foodstuffs can cause stomach upsets and more severe conditions related to food poisoning. The major sources of food contamination are from unhygienic food preparation and environments, undercooked or rancid meats, unwashed fruit and vegetables, etc.

Incapacitation Due to Food Poisoning (Gastroenteritis).

The most common cause of in-flight incapacitation resulting from food poisoning or drinking contaminated water, is acute **gastroenteritis**. The onset of gastroenteritis is usually abrupt and violent.

*A pilot suffering from **gastroenteritis** is not fit to fly.*

Symptoms of gastroenteritis include:

- Nausea.
- Vomiting.
- Abdominal pain.
- Loss of appetite.
- Diarrhoea which can cause a rapid loss of fluids.

Gastroenteritis is a debilitating condition. Pilots suffering from gastroenteritis are not fit to fly, even though they may be taking medicine which is relieving the symptoms.

PERSONAL HYGIENE.

A high standard of personal hygiene must be practised if the body is to remain healthy and free from infection. Some of the elementary precautions which help ensure personal hygiene are listed below:

- Careful and daily cleansing of the body, including scalp, gums and teeth.
- Washing and drying hands after using the toilet.
- Ensuring that eating utensils are scrupulously clean.
- Prompt treating and bandaging of minor cuts and abrasions.
- Regular exercise.
- Eating a balanced diet.

FITS.

Regular fits or seizures are a condition usually referred to as epilepsy. This is not a specific disease but a set of signs or symptoms in response to a disturbance of the electrical activity in the brain. Fits are often described as major or minor, although the distinction is not always clear. In a major fit, the sufferer may experience convulsions or uncontrolled movements. In a minor fit there may only be a short period of 'absence' or loss of attention. Many patients with epilepsy will have an abnormal Electroencephalogram (EEG) tracing with characteristic signs. An EEG may be used in the initial medical assessment of pilots or applied to pilots who may have had a disturbance of consciousness. Any fit, major or minor, is associated with an unpredictable loss of consciousness and is, therefore, usually a bar to the holding of a flying licence.

A fit is caused by an electrical disturbance in the brain.

FAINTING.

A faint is the more common cause of a loss of consciousness in adults. The causes of fainting are many: shock, loss of blood, lack of food or fluid, or other physiological stresses. The basic reason for a person fainting is a sudden reduction of the blood supply to the brain, commonly caused by:

Fainting is caused by a reduction in blood supply to the brain.

- Standing up quickly after prolonged sitting, especially when hot or dehydrated.
- A sudden shock.
- Loss of blood after an accident.

This form of attack has no sinister significance as far as future flying is concerned, as long as the cause is clearly understood. If a pilot suffers fainting attacks, he must, however, seek professional medical advice.

STROBOSCOPIC EFFECT.

In helicopter operations, it has been found that a limited number of people are affected by the stroboscopic effect of sunlight reaching the observer through the rotor blades. Problems are normally caused by flash frequencies between 5 and 20Hz; that is, between 5 and 20 flashes per second. This can lead to feelings of nausea, giddiness and, in extreme cases, cause an epileptic-type fit.

If a member of the crew or a passenger shows symptoms of the stroboscopic effect, the recommended preventative actions are:

- Turn the aircraft out of sun.
- Move the person affected to a seat in the shade.
- Make the individual close his eyes.

The wearing of sun glasses may also help reduce the stroboscopic effect.

FEELING UNWELL.

It is important to be aware that the in-flight environment may increase the severity of symptoms which may be minor while on the ground. Even minor ailments, such as a slight cold, or a stomach upset, can cause a deterioration of piloting performance. Consequently, if a pilot is feeling at all unwell, the decision whether or not to fly requires very careful consideration. If there is any doubt whatsoever in a pilot's mind about his fitness to fly, he should stay on the ground.

Pilots should never fly while suffering from a cold or flu, nor if they cannot clear their ears.

DRUGS AND SELF MEDICATION.

Whatever the primary purpose for which drugs or medication are intended, for example, to relieve the symptoms of an illness, it is generally true to say that most drugs and medicines have unwanted side-effects. Individuals will also vary in the way that the drugs and medication affect them. For these reasons, it is absolutely essential that pilots do not fly as part of the operating crew of an aircraft when taking drugs or medication, unless they have been cleared to do so by an Aviation Medicine Specialist. Self-medication is particularly dangerous. A pilot who takes charge of an aircraft while on self-prescribed medication not only runs the risk of suffering side-effects but also faces the hazards associated with the underlying illness in the in-flight environment which, as we have already stated, can make the symptoms of any illness much more debilitating than they might be on the ground.

The possible dangers of side-effects to medication may not be obvious, particularly when a mixture of drugs is contained in an apparently innocuous compound on sale to the general public in the local chemist. Be particularly aware that the precautionary advice contained on the packaging will not take into consideration the special problems associated with flying.

Listed below are some examples of ailments and the drugs and medication which can be purchased over the counter at any pharmacy to treat common ailments. The list gives you an appreciation of side-effects of the medication, highlighting the more dangerous agents. The list is by no means complete but gives an indication of the hazards involved in taking various types of medication.

Medicines to relieve the symptoms of Colds, Hay Fever and Flu:

Many of these contain anti-histamines which cause drowsiness and dizziness. The drowsiness can be particularly hazardous because it may not be recognised by the individual and may recur after a period of alertness. Anti-spasmodic drugs are often included in these compounds and these can cause visual disturbances. Quinine can also be present which can adversely effect hearing and cause dizziness.

Allergy Treatments:

Most of these contain anti-histamines which cause drowsiness and dizziness.

Nasal Decongestants:

Whether in drop or inhaler form, these contain stimulants which can cause sleepiness, nausea, depression, visual disturbances, impaired judgement and dizziness.

Diarrhoea Controllers:

These contain **opiates** which cause both nausea and depression.

Weight Controllers:

Most of these contain stimulants such as benzedrine or dexedrine which not only cause wakefulness but also nervousness and impaired judgement.

Stimulants and Tranquillisers:

These can cause sleepiness, nausea, depression, visual disturbances, impaired judgement and dizziness.

Caffeine.

Caffeine is present in coffee, tea, cocoa, chocolate, “energy” drinks such as Red Bull, and many fizzy soft drinks such as cola. Caffeine pills are also available, as an aid to keeping awake and alert. Caffeine is also found in medications for dieting, and the treatment of colds, allergies and migraines.

A typical coffee-drinker consumes 3.5 cups of coffee per day (containing 360 - 440mg of caffeine). You should be aware that a consumption of 6-8 cups of normal strength tea or coffee a day could lead to dependence, and that as little as 200mg of caffeine may reduce performance.

100 cups of coffee (10g of caffeine) consumed over a short period would probably prove fatal.

Excessive intakes of **caffeine**, over a period, can lead to:

- Ulcers and other digestive disorders.
- Increased risk of cardiac arrest.
- Hypertension.
- Personality disorders.
- Chronic muscle tension.
- Insomnia.
- Disorientation.
- Hyperactivity (especially in children).

The recommended maximum caffeine intake, per day, is approximately 250 - 300mg, corresponding to 2 - 3 cups of coffee.

ANAESTHETICS AND ANALGESICS.

A pilot should not fly for at least 48 hours following a general anaesthetic, and for at least 12 hours following a local anaesthetic.

If you undergo a local or general anaesthetic, a minimum period of time should elapse before piloting an aircraft. The period will vary considerably from individual to individual, but a pilot should not fly for at least 12 hours after a local anaesthetic and for 48 hours following a general anaesthetic.

The more potent forms of analgesics (pain killers) may produce a significant deterioration in human performance. If such analgesics are required, the pain for which they are being taken generally indicates a condition which means it is unsafe to fly. Refer to the reverse side of your UK CAA issued medical certificate to be informed of what you must notify your AME about and when.

ALCOHOL AND FLYING.

The chapter on ‘The Human Body’ teaches you about the nature of alcohol, its effects on the body and the dangers of combining alcohol consumption with flying. We return briefly to the subject, here, in the context of living a healthy lifestyle.

Alcohol is not digested in the human body. It is absorbed directly from the stomach and intestines into the bloodstream. From there, it is carried to every portion of the body. The liver is then responsible for eliminating the alcohol and does this by changing the alcohol into water and Carbon Dioxide. Drunkenness occurs when the individual drinks alcohol faster than the liver can dispose of it.

Alcohol is removed from the blood at a rate of approximately 15 milligrams per 100 millilitres per hour. The consumption of one and a half pints of beer, or three single whiskies, will result in a blood/alcohol level of about 45-50 mgm/100ml, and so it will take up to 4 hours for the blood level to return to normal.

Contrary to popular belief, a person cannot speed up the rate at which alcohol leaves the body. Black coffee and fresh air do not help. Eating during drinking will only slow up the rate at which alcohol is absorbed into the blood, not the amount of alcohol which is absorbed.

Once in the bloodstream, alcohol acts primarily as a depressant on the nervous system and slows down your reactions. Some critical areas of the brain, such as the decision-making areas, are especially vulnerable.

Long term consumption above the following levels can cause permanent damage to the body:

Government figures give the recommended maximum alcohol consumption figures as 21 units per week, for men, and 14 units per week, for women.

For men:

Three units daily, or 21 units per week.

For women:

Two units daily, or 14 units per week.

One unit is about a half pint of beer, a standard glass of wine or a measure of spirits. People who consume in excess of these amounts may develop a dependency for alcohol.

The World Health Organisation definition of an alcoholic is: ‘A person whose excessive use of alcohol repeatedly damages his physical, mental, or social life’.

Remember that even small amounts of alcohol will degrade your performance as the pilot of an aeroplane or the driver of a car. It is a criminal offence to drive a car or pilot an aeroplane while under the influence of alcohol.

The United Kingdom Civil Aviation Authority strongly advises that pilots should not fly for at least 8 hours after consuming even small amounts of alcohol, and proportionally longer if larger amounts are consumed. It is prudent for a pilot to abstain from alcohol for at least 24 hours before flying.

Joint Aviation Regulations specify a maximum blood alcohol limit for pilots of 20 milligrams per 100 millilitres of blood.

TIREDNESS AND FATIGUE.

Tiredness and fatigue, though related concepts, differ in their long term physical effects on the body. Ordinary tiredness results from normal physical and/or mental exertion over a normal waking period, say, 14 hours. If a person is tired in this way, a good night’s sleep is the only requirement for that person to be fit the following morning to continue with physical activity, whether that be flying or any other kind of work. The only consideration required to deal with normal tiredness is to ensure that periods of activity and periods of restful sleep comply with the normal pattern for a person’s age and physical condition.

Fatigue, however, is a very deep tiredness due to the cumulative effects of a stressful lifestyle and/or living and working environment.

Whereas normal tiredness is instantly recognisable by the sufferer, and the remedy obvious, the effects of fatigue can be gradual; they can creep up slowly on the sufferer. Moreover, the sufferer may, for a number of reasons, be unwilling to recognise or admit that he is suffering from fatigue.

The important fact for pilots to be aware of is that both tiredness and fatigue can kill them and their passengers. There are differences, however, in a person's perception of, on the one hand, tiredness, and, on the other hand, fatigue.

Pilots may quite readily decline to fly when they are normally tired. But a pilot suffering from cumulative fatigue may not realise his condition, or be unwilling to admit it. Fatigue, then, is a highly dangerous condition for a pilot. Pilots, therefore, must be conscious of the symptoms of fatigue and be prepared both to recognise the symptoms and to admit to them.

Fatigue can be caused by the following circumstances:

- Long-term ill health, either physical or mental.
- Regular sleep-deprivation, for whatever reason.
- High levels of stress and/or anxiety over a prolonged period.
- A disturbed body cycle. (e.g. jet lag, changing work-shift patterns).
- Long-term difficulties in personal or work-based relationships.
- A stressful living and/or working environment (e.g. high levels of noise, or unreasonable physical or mental demands).

Symptoms of fatigue may be:

- Diminished awareness.
- An appearance of tiredness.
- Diminished coordination.
- Memory lapse.
- A propensity to make frequent mistakes in speech and actions.
- Rapid changes of mood.

If you become aware that you have developed symptoms of fatigue, do not fly again until you have consulted a doctor. If you are a professional pilot, the doctor should be an authorised aviation medical specialist.

As a minimum and immediate self-help programme, you might also consider the following:

- Accept the fact that you may be fatigued.
- Make sure that you get regular, undisturbed sleep.

Customer: Oleg Ostapenko E-mail: ostapenko2002@yahoo.com

- Avoid alcohol and caffeine.
- Eat a balanced diet of appropriate quantities of food.
- Try to take the stress out of your life.

Always, however, consult a doctor.

SUSCEPTIBILITY AND TOLERANCE TO G FORCES.

As we have already mentioned, flying can expose the human body to conditions for which it is not naturally suited. We have covered, for instance, extremes of pressure and their effect on Oxygen intake, in some detail. Here we will look at the increase and decrease in gravitational force, or, more accurately, gravitational acceleration, to which the body may be exposed in flight. Gravitational acceleration is often referred to colloquially as “g” or “g-force”.

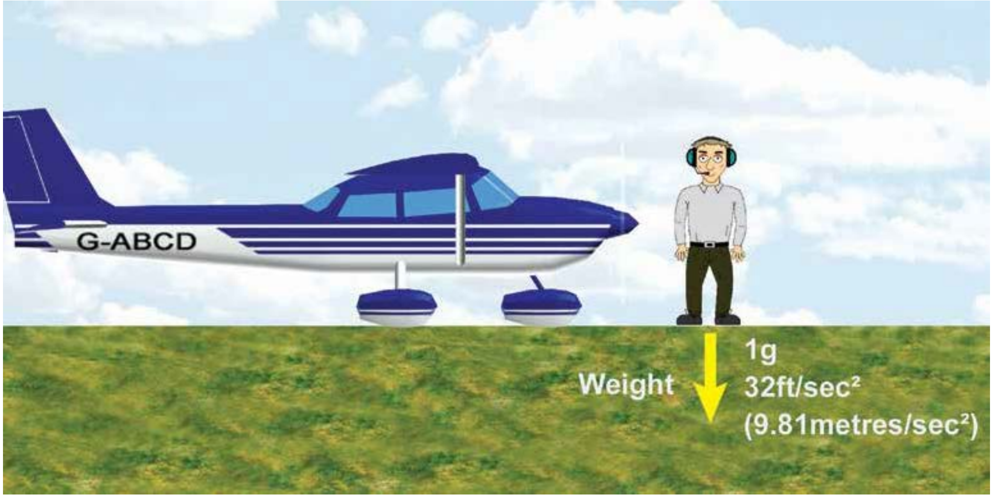


Figure 7.6 Normal Gravitational Acceleration of 1g.

Positive g.

Under normal conditions on the ground, the body is subject to 1g; that is, ‘normal gravitation acceleration’ of 32 feet per second squared or 9.81 metres per second squared, directed towards the centre of the Earth. (*See Figure 7.6*)

The reaction of the surface on which we are standing or resting gives us the sensation we call weight. You will be experiencing a 1g acceleration as you sit in your chair reading this book.

A pilot will also experience **1g** in straight and level flight. But if he carries out a level turn at 60 degrees of bank (*See Figure 7.7*), he will be subject to an acceleration of 2g acting vertically through his seat (If his turn is perfectly executed, that is). As body mass is constant, the pilot’s weight will also increase by a factor of 2. This factor of 2 is called the load factor. In a 60 degree level turn, the whole structure of the aircraft is subject to a load factor of 2.

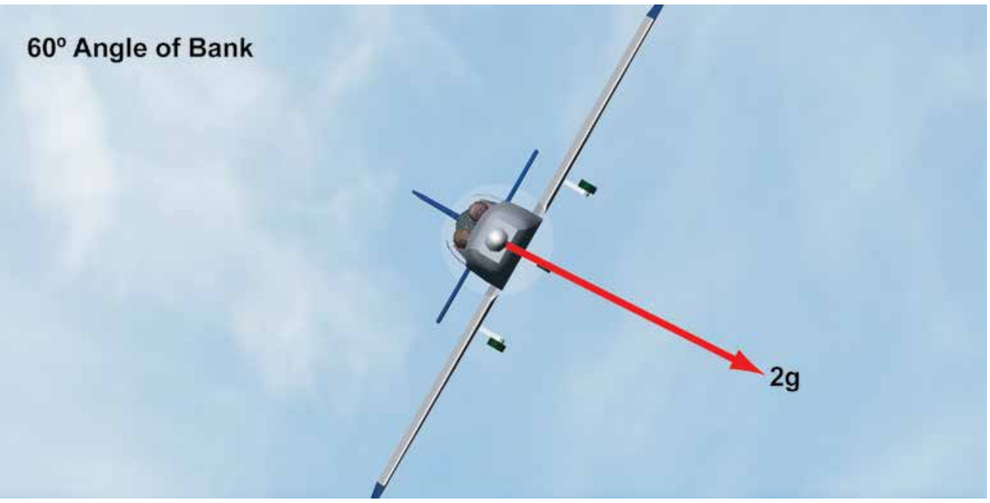


Figure 7.7 In a 60º-banked turn, a pilot is subjected to an acceleration of 2g.

In a 70 degree level turn *(See Figure 7.8),* should your aircraft's engine be powerful enough to perform this manoeuvre, the load factor increases to 3. In aerobatics, a pilot may experience accelerations and load factors of this order. In fact, a typical light aircraft cleared for aerobatics would be stressed to withstand positive load factors of up to six.

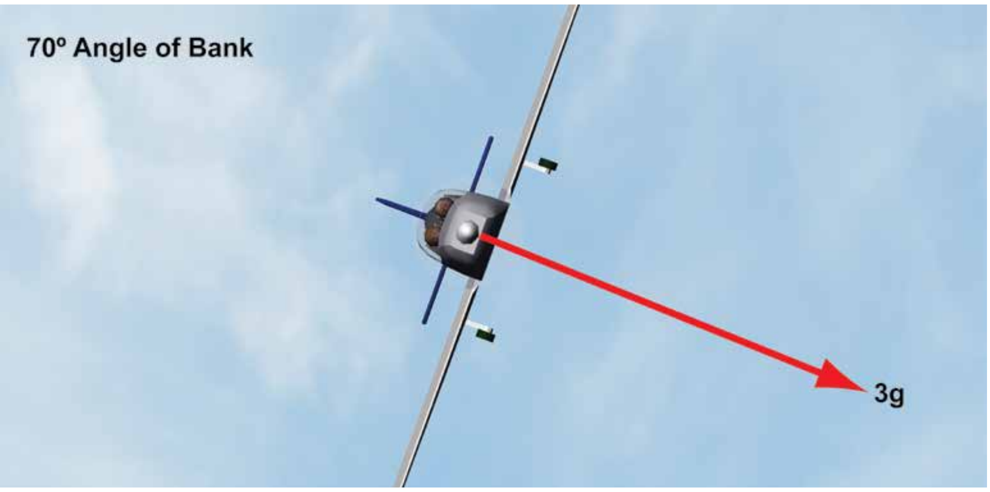


Figure 7.8 In a 70º-banked turn, a pilot is subjected to an acceleration of 3g.

Let us now look at the effect of increased accelerations, or increased g, or load factors, on the body. During increased g manoeuvres, the pilot's head becomes heavy, mobility is impaired and the body's internal organs can be displaced slightly. Blood will also be drawn towards the lower parts of the body as the heart's ability to pump blood into the brain is overcome by the increased load factor.

As g increases, the pilot's peripheral vision becomes impaired, and his view of the world turns grey. The expression **grey out** is used to describe this condition.

If g is further increased, the pilot's sense of vision may cease to operate, and he is said to black out. It is easy to imagine that the pilot may lose both consciousness and control of his aircraft, with possible catastrophic consequences. Loss of consciousness (GLOC) occurs after blackout as eyes are more sensitive to loss of blood pressure than anything else.

The adverse effects of moderately increased **g** can sometimes be delayed or relieved by tensing the thigh and stomach muscles. The quickest way to relieve black out or grey out is to ease off the backward pressure on the control column. Speak to your flying instructor about subsequent actions as they apply to your aircraft.

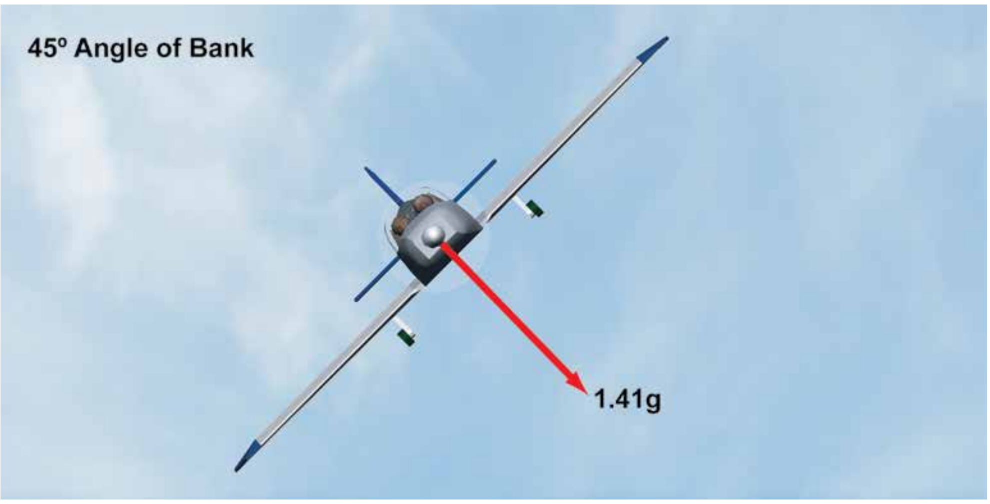


Figure 7.9 In a 45º-banked turn, a pilot is subjected to an acceleration of 1.41g.

Under normal circumstances, a private pilot of a light, touring aircraft, without aerobatic training, should never find himself subject to accelerations of more than 1.41g. 1.41g is the acceleration experienced in a level turn at 45 degrees angle of bank. In normal, touring flying, angles of bank greater than this are unnecessary.

It is important however, to understand the circumstances which can give rise to higher values of **g** and the effects that the associated higher loadings can have on the body. Tolerance to **g** may be reduced by:

- Excessive alcohol consumption.
- Smoking.
- Fatigue.
- Excessive heat.
- Obesity.
- Any level of illness.

Factors affecting tolerance to 'g' include:

- *Alcohol.*
- *Smoking.*
- *Fatigue.*
- *Excessive heat.*
- *Obesity.*
- *Any level of illness.*

Negative g.

Whereas most pilots can learn to tolerate moderate increases in positive g, many pilots find even the smallest exposure to negative g to be unpleasant. You may already have experienced negative g if you have ridden on a rollercoaster or driven at speed over a hump-backed bridge.

During flight, negative g is experienced if, after pulling out of a steep dive, the control column is instinctively and firmly moved forward again because the pilot feels that he has his nose too high in an attitude that may lead to a stall. You will almost certainly have this phenomenon demonstrated to you during training and will be taught the difference between this sensation and the sensation experienced during a stall.

From the point of view of physical sensation, you should know that negative g manoeuvres increase the flow of blood to the head. Blood pressure in the head increases, the face becomes very flushed, often painfully so, and the eyes begin to bulge.

In extreme cases, blood vessels may burst. The combined effect of the aforementioned symptoms causes what is described as a red out. Ultimately, consciousness may be lost with the obvious attendant dangers.

Immediate relief from the symptoms may be obtained if the pilot ceases to push forward on the stick, selects a normal flying attitude and waits for normal flight conditions to re-establish themselves. As always, be sure to consult your instructor's advice on piloting issues.

TOXIC HAZARDS.

The word **toxic** derives from Latin and Greek words meaning "poisonous". The operation and engineering support of aircraft involve the use of many substances which are, in themselves toxic or produce toxic fumes, either spontaneously or when burned. Even mild **toxic** effects can degrade a pilot's performance and lead to an accident. Prolonged exposure to toxic influences can damage a person's general health. It is, therefore, of crucial importance that pilots recognise the dangers posed by toxic substances so that they may act accordingly in their presence. In an unpressurised aeroplane, the general noxious fumes drill is to ventilate the cabin and land as soon as possible.

One of the greatest toxic dangers is exposure to Carbon Monoxide fumes in flight. This subject is covered fully in the chapter on The Human Body.

Explanation of Other Toxic Hazards.

Fuels, lubricants and propellants can release irritant vapour which may cause drowsiness or irritation to the respiratory system, together with skin damage. Hydrocarbons and Tetra Ethyl Lead can affect the nervous system causing a loss of sensation. Among the senses affected is that of smell which diminishes an individual's awareness of continued exposure to toxic hazards.

Anti-icing fluid gives off fumes which, if allowed to enter the fuselage, can be harmful. Ethylene Glycol, which is often used as an anti-icing fluid, can cause kidney damage.

Fire extinguishing agents, particularly BCF, cause suffocation, lung irritation, dizziness, confusion and coma, if ventilation is inadequate.

Batteries, when improperly mounted or packed, can leak dangerous acid fumes. Mercury batteries are especially dangerous, as any spilt mercury will very rapidly corrode aluminium structures of an aircraft.

In the case of fire on board the aircraft, some cabin furnishings and plastic or foam upholstery give off poisonous fumes as they are heated. There is always the chance that luggage may also contain lethal items which may have passed a less-than-rigorous screening. (The tragic Saudia accident, which killed over 300 people as a result of toxic fumes, is a prime example of this very real danger.)

Acetone and Turpentine, which are both used in aviation, can damage membranes and eyes

Anyone who has been exposed to any toxic hazard should seek medical assistance, as soon as possible.

Toxic hazards in aircraft are as follows:

Anti-icing fluids *(can cause kidney damage).*

Fire extinguishing agents *(can cause suffocation, lung irritation, dizziness, confusion and coma).*

Batteries *(can leak acid or mercury - highly corrosive).*

Baggage and furnishings *(can cause poisonous fumes in the event of a fire).*

Acetone *and* ***Turpentine*** *(can damage eyes and membranes and are a fire hazard).*

Dangerous Cargo.

Pilots must be aware that they must not carry certain defined items on board their aircraft. Such items are referred to as dangerous cargo because of the possibility that their discharge, spillage or breakage may endanger the aircraft and/or crew in flight or on the ground. Among items classified as dangerous cargo are:

- Compressed gas containers.
- Toxic substances.
- Acids and other corrosive liquids.
- Radioactive materials.
- Firearms.

Further information about dangerous goods and aviation may be found in **Civil Aviation Publication (CAP) 668,** available from the United Kingdom CAA.

PASSENGER CARE.

On completion of your training, as the holder of a private pilot's licence, you will be able to carry passengers with you when you fly. Taking friends and family into the air is one of the privileges and pleasures of holding a pilot's licence.

The privilege, however, also carries with it an enormous responsibility: that of the pilot for the care, comfort and safety of his passengers.

A pilot's responsibility for the care of his passengers commences with the pre-flight briefing of passengers and lasts until the passengers have safely disembarked from the aircraft and have left the operating area of the airfield. We will look at passenger care for each of the following phases of the flight:

- Pre-flight briefing.
- Approaching the aircraft, embarking and strapping in.
- In-flight procedures.

- Emergencies.
- Disembarkation.

The CAA publish a free comprehensive guide to Care of Passengers on their website. http://www.caa.co.uk/application.aspx?catid=33&pagetype=65&appid=11&mode=detail&id=1157

The Pre-Flight Briefing of Passengers.

The best way to give your passengers confidence in your ability to take them safely into the air and to bring them safely to earth again is to deliver a thorough pre-flight briefing in a confident and reassuring manner.

UK Air Law requires that the Pilot in Command of an aircraft should give a pre-flight briefing to all passengers being carried in a UK-registered aircraft. During the pre-flight briefing, passengers should be given brief information about the nature of the flight; for instance, whether it is to be a local, sight-seeing flight or a cross-country or route flight.

For any passengers who have never flown before, it is useful to say a word or two about the sensations of flight. You should put them at their ease and mention practical issues such as the pressure changes associated with climbing and descending, and how the ears may be cleared. If the day of the flight is one where significant weather conditions prevail, mention them in your briefing. If cloud is extensive, or if turbulence is present, it will reassure passengers to be told about them before they get airborne.

It is customary for information on any standard emergency procedures to be given during the pre-flight briefing. If parachutes are to be worn, the pre-flight briefing is the time to brief your passenger or passengers on how to put on the parachute, how to exit the aircraft, how to deploy the parachute and how to steer it and land. The brief on abandoning the aircraft should be repeated prior to take-off. In most light aircraft, however, parachutes will not be worn.

It is always worthwhile mentioning that airfields can be cold and windy places, even in warm weather, and that warm clothing should always be available. (It can always be removed before boarding the aircraft.) The Pilot in Command should emphasise that no loose articles are to be carried, and that coins should be put in closed pockets, and pens safely stowed.

At this stage, the pilot must make a final check that the weight of his passengers, his own weight, and that of any other payload, such as luggage, parachutes, Mae-Wests (life-jackets) or other emergency equipment, do not exceed permitted all-up-weight. Aircraft Centre of Gravity limits must also be calculated and checked, at this stage.

Finally, while you are still in the crew room, you should ask if any of your passengers have any questions to ask you.

Approaching the Aircraft.

Brief your passengers thoroughly on how they are to cross aprons or other manoeuvring areas and taxiways, and how they are to approach the aircraft. *(See Figures 7.10 and 7.11.)* Check whether high-visibility jackets need to be worn at your airfield. In approaching the aircraft, the passengers must be warned to stay well clear of the propeller arc. *(See Figure 7.12.)*

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Figure 7.10 On the Apron.

Figure 7.11 Approaching the Aircraft.

Figure 7.12 Steer Clear of the Propeller Arc!

Embarkation and Strapping in.

The aircraft's engine must be shut down during passenger embarkation. Ideally, the aircraft should be approached obliquely from behind. If there are several passengers, they should keep in one group so that you can supervise them efficiently. Ensure that the passengers are comfortably seated and correctly strapped in. Refer to your aircraft's handbook for details on strapping in.

The thorough pre-flight briefing of passengers is essential.

Passengers must be fully briefed on how to do up, adjust and release straps and harnesses. Ensure that passengers understand how to adjust and lock their seats.

The passenger who sits in the front in the right hand seat will need to be briefed that he should not permit any part of his body or equipment to interfere with your operation of the aircraft controls. The operation of doors, windows and direct-vision panels and ventilation ports must be fully explained. It is the responsibility of the Pilot in Command to check that all doors are closed and locked.

Check that headsets are properly fitted and adjusted and that operation of the Intercom is understood. You may wish to explain that talking on the Intercom should be kept to a minimum because of your need to speak on the radio and to concentrate on the safe conduct of the flight. You should, nevertheless, encourage your passengers to point out to you anything of concern to them or to ask any questions they wish about the flight. It is useful to take advantage of the extra pair, or pairs, of eyes and to ask for help in maintaining a good look out for other aircraft, or for significant ground features.

Immediately Before Take-Off.

Before you make first contact with Air Traffic Control, remind passengers about action to take in the event of a forced landing, and the use of any emergency equipment. Finally, if parachutes are worn, the procedure for abandoning the aircraft should be gone through again.

In Flight Procedures.

If your pre-flight briefing and embarkation procedures have been effective, there should be no need for any <u>formal</u> briefings or procedures during the flight itself.

Do, however, re-assure passengers, if anything unusual should occur, such as flying through turbulent air. Be sure to point out interesting and relevant features in the air and on the ground. Also, keep passengers updated about the progress of the flight. If you are flying a route, they should be told about position and estimated time of arrival at the destination. Whether en route or during a local flight, it is a good idea to advise, in advance, passengers who fly infrequently that you intend to turn, or execute a climb or descent. They will not, then, be surprised by an unexpected manoeuvre.

Emergencies.

An emergency can occur in the air or on the ground. However, in the air, during an emergency, events happen quickly and the pilot's concentration is fully occupied with dealing with the immediate safety of the aircraft and passengers. Therefore, instructions to passengers on how they should react to an emergency must be given on the ground, in the aircraft, where possible. The Pilot in Command must familiarise himself with the emergency procedures and equipment pertaining to the aircraft he is about fly, and with the specific emergency equipment made available to the passengers.

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Forced Landings.

A forced landing is any emergency landing on a surface other than an airfield runway. A forced landing may be necessary following an engine failure. Fortunately such occurrences are rare. As in everything in flying, though, you must be prepared for the worst. A summary of the forced landing briefing is shown in *Figure 7.13*.

Identify and know the location of your aircraft's emergency equipment, and be familiar with its operation.

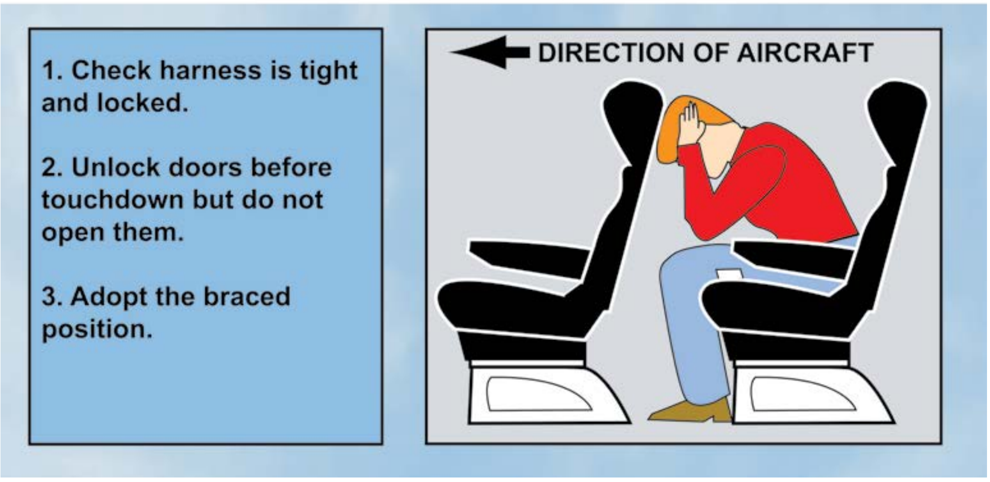

Figure 7.13 Summary of Forced Landing Briefing.

The aim of the forced landing briefing is to prevent passengers being injured through striking any objects within the aircraft, and to enable them to vacate the aircraft quickly and safely. If a forced landing over land is inevitable, you must warn your passengers of the occurrence and order them to check that their harnesses are tight and locked. Before touching down, doors must be unlatched but not opened.

Headsets should be removed and put aside just before touch-down. Again, just before touching down, passengers must adopt the braced position. The passengers must know the most efficient evacuation order and how to unlock seat and back-support restraints.

Briefing for a Forced Landing on Water.

When flying over water in a twin-engined aircraft, passengers need to be instructed in the location of life-jackets and how to put them on. In a single-engined aircraft, however, life-jackets must be worn. It is not sufficient merely to have life-jackets available for donning. Passengers must be briefed on how to inflate their life-jackets and how to use any ancillary items such as whistles, radio-beacons and lights (*See Figure 7.14*.) It is of vital importance to stress that no passenger must inflate his life-jacket until he is outside the aircraft, following ditching.

If a life-raft or dinghy is carried, make sure that someone is made responsible for deploying it on ditching. Procedures for inflating and boarding life-rafts must be followed exactly. As Pilot in Command, it is your responsibility to get yourself instructed on the details pertaining to the equipment you carry, and to brief passengers before flying.

Abandoning the Aircraft by Parachute.

As already mentioned, a passenger must be briefed, before embarkation, on donning the **parachute**, exiting the aircraft, deploying the chute, steering it and landing.

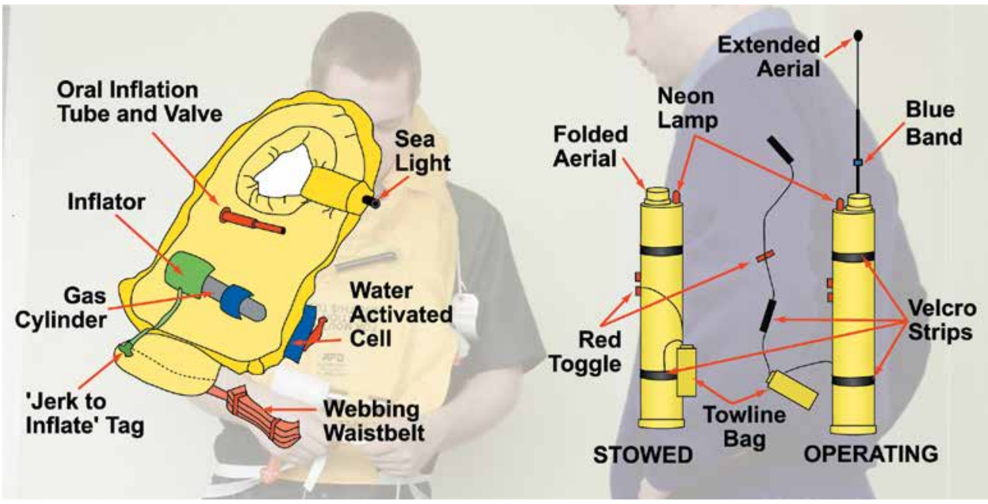

Figure 7.14 Life-jacket and Transponder.

This briefing is specialised and, except for the landing, dependent on the type of parachute worn, and aircraft type.

Once again, it is the Pilot in Command's responsibility to be thoroughly briefed on the parachutes he and his passengers are using and the bailing out procedures for his particular aircraft.

Knowledge of First Aid.

Although there is no test in **first aid** for private pilots in Britain, a pilot who does not possess a rudimentary knowledge of first aid may be considered as unable to fulfil his duty of care to the passengers he carries in his aircraft or accompanies onto the airfield. This book does not aim to teach you first aid. You should enrol on, and complete, a course in first aid run by a recognised and competent organisation such as the St John Ambulance (**www.sja.org.uk**), or the Red Cross (**www.redcross.org.uk**).

A knowledge of first aid skills will be essential if, for instance, persons in your care injure themselves on the airfield or sustain injuries following a forced landing. You can save life or minimise the consequences of injury if you know what to do between the time of injury and the arrival of qualified medical help. So get yourself trained in first aid.

In principle, at the scene of an accident, your first aid priorities should be:

- Do nothing to aggravate the situation or further injure a casualty.
- Do, however, remove a casualty from immediate further danger.
- Summon specialist help by the quickest possible means and ensure that the emergency services know how to reach you. (For instance, position someone at the airfield entrance, and know how to summon the emergency services at your home airfield.)

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- Administer first aid – Remember the mnemonic ABC:

  A = Airways:- Clear obstructed airways.

  B = Breathing:- Ensure that the injured person is breathing again; (consider artificial respiration).

  C = Circulation:- Stop any bleeding.

Finally, make sure that your aircraft and your club-house are equipped with a first aid kit whose contents meet the recommendation of the Air Navigation Order, and that you know what those contents are. Ensure also that you know how to locate the first aid kit.

Representative PPL - type questions to test your theoretical knowledge of Flying and Health.

1. The body mass index is obtained by:

   a. Multiplying body weight in kilograms by height in metres squared
   b. Adding body weight in kilograms to height in metres squared
   c. Multiplying body weight in pounds by height in feet squared
   d. Dividing body weight in kilograms by height in metres squared

2. A body mass index of 23 for a male or female pilot indicates he/she is:

   a. Underweight
   b. Normal
   c. Overweight
   d. Obese

3. In order to be effective, exercise should be:

   a. Sufficient to double the resting heart rate for 20 minutes at least twice per week
   b. Sufficient to halve the resting heart rate for 20 minutes, at least three times per week
   c. Sufficient to double the resting heart rate for 20 minutes, at least three times per week
   d. Sufficient to double the resting heart rate for 30 minutes, at least twice a week

4. Breakfast should supply:

   a. At least 25% of the daily calorie intake
   b. Sufficient calories to spend a whole day at the airfield
   c. Enough protein to make up 50% of the daily calories consumed
   d. A high fat start to the day to give energy and reduce the risk of heart disease

5. An intake of iron is essential for:

   a. Improving personal magnetism
   b. The manufacture of haemoglobin
   c. The production of Rhodopsin to improve night vision
   d. Building and maintaining healthy bones and teeth

6. The condition of Gastroenteritis makes a pilot:

   a. Fit to fly
   b. Fit to fly if no attack has been experienced for an hour
   c. Fit to fly provided appropriate medication is being taken
   d. Unfit to fly

7. A fit or seizure is symptomatic of:

   a. An interruption of the blood supply to the pulmonary system
   b. A reduction in the blood supply to the brain
   c. An electrical disturbance in the brain
   d. The failure of the pancreas to produce insulin

8. The recommended maximum daily caffeine intake is approximately:

   a. 150 – 200mg
   b. 200 – 250mg
   c. 250 – 300mg
   d. 300 – 350mg

9. The maximum number of units of alcohol is 21 for men and 14 for women. These limits are:

   a. Per day
   b. Per week
   c. Per month
   d. Per year

10. If a pilot is suffering from a cold or flu, he:

   a. Is unfit to fly
   b. Is fit to fly if taking appropriate medication
   c. Is fit to fly if no sneezing has being experienced for one hour
   d. Is fit to fly if he can clear his ears

11. A pilot is 2 metres tall and weighs 90 kilograms. What is his Body Mass Index and is he over-weight?

   a. 40; yes
   b. 22.5; no
   c. 22.5, yes
   d. 40; no

12. What angle of bank, in a balanced turn, will subject the body to an acceleration of 2g?

   a. 15°
   b. 60°
   c. 30°
   d. 45°

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13. What is the best way for a pilot to reassure any nervous passenger whom he is about to take flying?

    a. To allow the passenger to see his pilot's licence
    b. To show the passenger his log book which is a record of his experience of safe flying
    c. To explain to the passenger how much other people have enjoyed flying with him
    d. To give the passenger a thorough pre-flight briefing, following established and approved guidelines

14. For what period of time must a pilot refrain from flying after being given an anaesthetic?

    a. 24 hours following a local anaesthetic and 48 hours following a general anaesthetic
    b. 12 hours following a local anaesthetic and 24 hours following a general anaesthetic
    c. 12 hours following a local anaesthetic and 48 hours following a general anaesthetic
    d. 24 hours following both local anaesthetic and a general anaesthetic

15. At what rate does the body remove alcohol from the blood?

    a. 100 milligrams per 15 millilitres per hour
    b. 50 milligrams per 100 millilitres per hour
    c. 15 milligrams per 100 millilitres per hour
    d. 120 milligrams per 80 millilitres per hour

16. Which of the answer options below includes three important health risks to which obese people are exposed by virtue of excessive body weight?

    a. Heart attack, blood circulatory problems, hypertension
    b. Myopia, loss of appetite, nausea
    c. Insomnia, disorientation, muscular tension
    d. Memory lapse, diminished awareness, lack of coordination

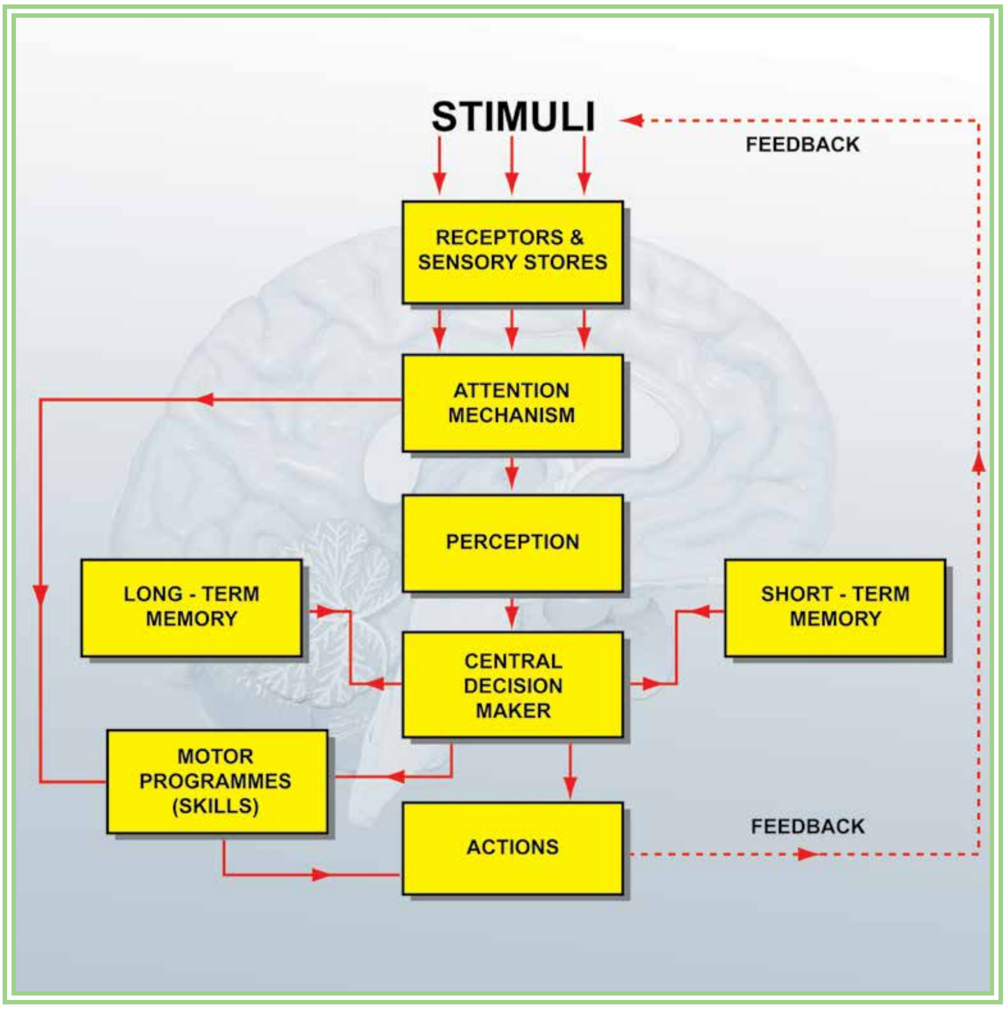
Question	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
Answer											

Question	**12**	**13**	**14**	**15**	**16**
Answer					

The answers to these questions can be found at the end of this book.

CHAPTER 8

THE INFORMATION PROCESS



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INTRODUCTION.

We receive information from the world around us through our senses: sight, hearing, touch, smell and taste. When flying an aircraft, the pilot must observe and react to events both in the cockpit and in the environment outside the aircraft. The information from the pilot's senses must be interpreted in order that he may make decisions and take actions to ensure the safety of his aircraft at all times.

In this chapter, we will lay out the basic system by which we receive and process information in order to make decisions, and recognise where errors in the system may be the cause of accidents.

BASIC INFORMATION PROCESSING.

The processes of thought and decision-making (collectively known as reasoning) arise from electro-chemical currents within the brain. *Figure 8.1* represents a functional model of the various stages of our reasoning which occur between receiving information and a response being made. These stages are:

- Detection (information is received).
- Perception.
- Decision.
- Action (responses are selected and executed).
- Feedback.

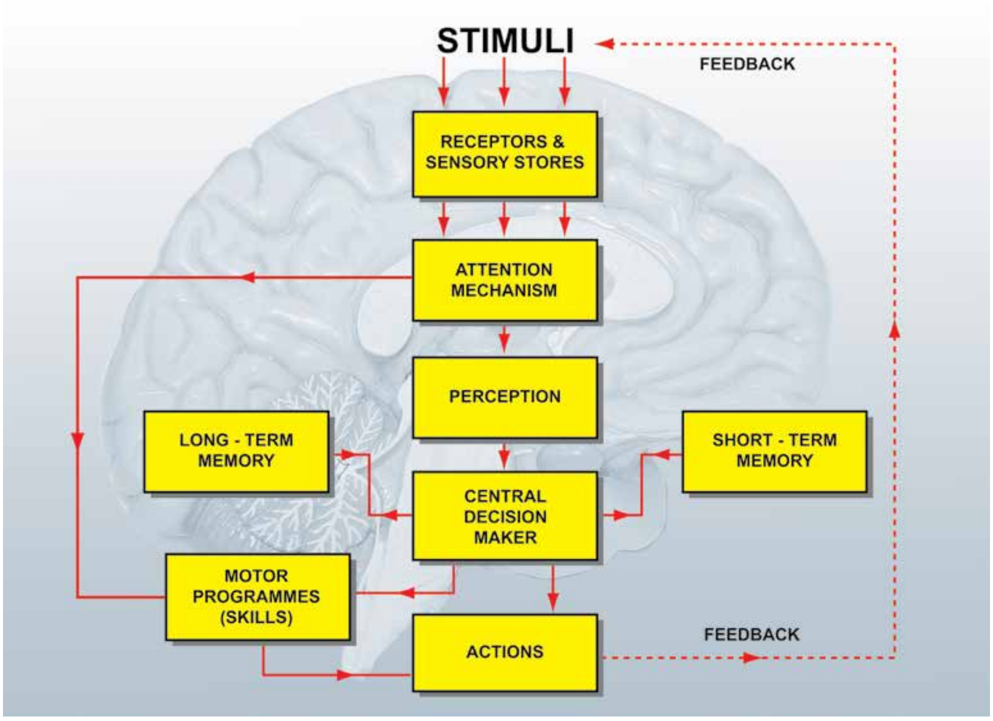

Figure 8.1 Basic Information Processing.

The model at *Figure 8.1* is of some importance when attempting to determine how errors occur. With the help of the model, we can determine whether the errors result from a failure of perception, a failure of memory, or whether, in spite of having correctly interpreted the information, a person has simply failed to take the correct action. The functional model also helps in understanding other factors, such as stress, which may influence a person's performance.

THE BRAIN, (THE CENTRAL DECISION MAKER) AND RESPONSE SELECTION.

Once information about a particular event has been perceived, a decision must be formulated, and a response made. For example, on hearing a warning sound the operator of a machine, such as the pilot of an aircraft, may switch off the affected system (a selected response) or hold the information in memory whilst a search is made for the problem which has triggered the warning.

Information is continuously entered into, and withdrawn from, both the long and short-term memories in order to assist the decision process. For example, Air Traffic Control may instruct a pilot to change the frequency of his radio. The new frequency will be stored in the short-term memory. However, knowledge of the action necessary to select the frequency will be stored in the long-term memory.

We sometimes feel that we can make several decisions at the same time. This is strictly untrue, since the Central Decision Maker (the brain) can only process one decision at a time. This is the chief limitation of the brain. Making one decision at a time is known as single channelled processing. But, if it was the only process by which human beings could take action, multi-tasks (such as flying an aircraft and holding a conversation) would be impossible. Fortunately, men and women also possess a faculty which governs motor programmes or skills, and which allows them to carry out already-acquired skills, while freeing up reasoning ability so that they can multi-task.

MOTOR PROGRAMMES (SKILLS).

Introduction.

Motor programmes, or skills (sometimes referred to as procedural memory), are learnt by practice and/or repetition. These skills are believed to be held within the long-term memory and can be carried out without conscious thought. To take an obvious example, when a person walks, the action requires little conscious attention. The skills required to walk have been stored in the long-term memory.

A motor programme, or skill, is an organised and co-ordinated pattern of activity which may be physical, social, linguistic or intellectual.

Developing Motor Programmes.

In developing a motor programme or skill, there are three distinct phases:

- The cognitive phase, in which the learner thinks consciously about each individual action.

- The associative phase, in which the separate components of the overall action become integrated.

- The automatic phase, when the complete action is executed smoothly without conscious control.

REFLEXES.

Although **reflexes** are actions which are driven by components of the body's nervous systems, they occur with little or no involvement of the central nervous system. When a reflex action is required, such as when a person's hand touches something very hot, the motor nerve, which controls muscular action, (i.e. movement to withdraw the hand), is linked very closely to the sensory nerve which feels the heat, so that the central nervous system is essentially by-passed, and the muscular action occurs with hardly any processing within the central nervous system taking place.

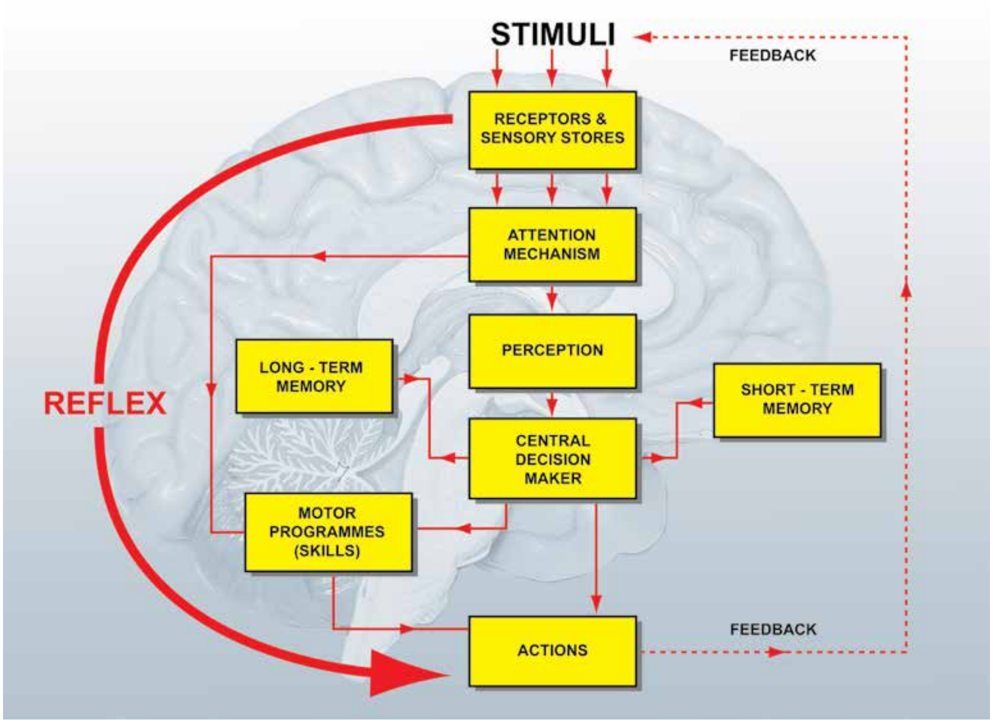

Figure 8.2 Reflex Action.

Reaction Time.

There is a delay between detection, stimulus, and muscle contraction. This delay is called reaction time. Reaction time depends on the type of reflex action required. There are three types of reflex action: unconditioned, conditioned, and trained.

The Unconditioned Reflex.

Unconditioned reflexes are instinctive natural reflexes, such as blinking (when something moves towards the eye) or removing a hand from a hot surface. This type of reflex has the shortest reaction time since the brain does not process it.

Figure 8.3 Unconditioned Reflex.

The Conditioned Reflex.

These are reflexes that may be learned. An example of a conditioned reflex is that of Pavlov's dogs. Dr. Pavlov sounded a bell at the same moment that food was offered to a dog. Over time, the dog became so conditioned that its mouth would water anytime it heard a bell, even when food was not present.

The conditioned reflex has the second fastest reaction time since the brain does not have to process sensory input. The brain is conditioned to respond directly to the input without conscious thought *(see Figures 8.4 and 8.5)*.

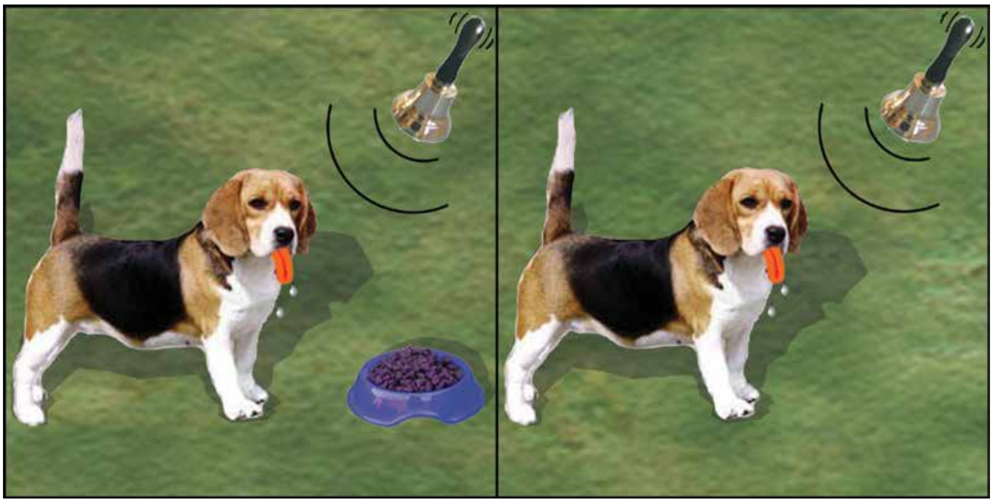

Figure 8.4 and Figure 8.5 Conditioned Reflexes - Left, dog responding to bell and food; Right, dog responding to bell alone.

The Trained Reflex.

Trained reflexes are reflexes which may improve through repeated practice. If a pilot practises emergency drills frequently, he will become more proficient.

The trained reflex is a conscious reaction to a sensory input. This type of reflex has the slowest reaction time but, with continuous training over a long period, it may develop to the point where reaction time is as short as for an unconditioned reflex. The pilot must make sure, however, that he does not place more importance on the speed of the reaction, than on the accuracy of the action. Reaction to a fire in the air, for instance, requires the vital actions to be carried out accurately as well as rapidly.

CONCEPTS OF SENSATION.

Stimuli.

The senses of sight, hearing, taste, smell and touch provide inputs (stimuli) to our brain. Some stimuli are stored for a brief time after the input has finished. Others are stored for a lifetime. For example, what person forgets the taste of his mother's cooking or the touch of velvet?

Sensory Threshold.

Stimuli must be of a certain strength for the sensory receptors to pick them up. In other words, a sound must be of sufficient strength to be received, or a shining light strong enough to be perceived. This minimum strength is known as the sensory threshold.

MEMORY.

There are three types of memory:

- Sensory memories (sometimes referred to as ultra short-term memories).
- Short-term (or working) memory.
- Long-term memory.

SENSORY MEMORIES.

The key feature of the sensory memories is that there is a separate memory store for each sensory system.

The sensory stores of touch, taste and smell are of little significance in aviation. However, the sensory stores of sight and sound are important, and the pilot needs to know about these.

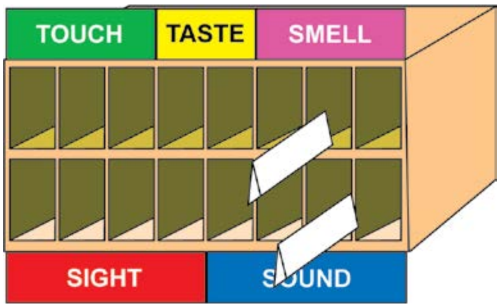

Figure 8.6 There is a separate memory store for each sense.

Sensory Memory for Sound - The Echoic Memory.

The echoic memory retains information for between 2 and 8 seconds. For example, it is possible to recall the chimes of a clock that have struck, but only up to the third or fourth stroke, unless you consciously count the strokes.

Up to about the fourth stroke, the echoic memory may be replayed and interrogated to enable the strokes to be counted consciously. The important factor, here, is that the echoic memory needs to hold an input long enough for the input to be scanned for relevance. If an input is of interest, then it is transferred into the short term memory.

Sensory Memory for Sight - The Iconic Memory.

The iconic memory is the visual sensory store. The iconic memory retains information for between 0.5 and 1 second only. 80% of information processed by human beings enters the brain through this visual channel.

For example, imagine that you are driving down a road maintaining a normal visual scan. Within a second of passing a particular road sign you will, normally, have forgotten it. If you were on a driving test, though, you might make a conscious decision to remember the road signs that you pass.

Sensory Adaption (Habituation).

A special characteristic of all sensory receptors is that they adapt, either partially or completely, to their stimuli after a period of time. That is, when a continuous stimulus is first applied, the receptors respond at a very high impulse rate at first, then progressively less rapidly until, finally, many of the receptors no longer respond at all. This is why, once you get dressed, you do not continue to feel your clothes against the skin.

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SHORT TERM MEMORY (WORKING MEMORY).

Introduction.

The attention mechanism *(See Figure 8.2)* will select what information is passed to the short-term memory. The short-term memory enables information to be retained for a short period of time. Information will be lost after 10 to 20 seconds unless it is actively rehearsed and deliberately placed in the long-term memory. Unless rehearsed, items are lost through interference from new information, or even from information previously stored.

Limitations of Short-Term Memory.

The capacity of our short-term memory is limited. The maximum number of unrelated items which can be maintained in the short-term memory is about 7 ± 2. Once this limit is exceeded, one or more of the items are likely to be lost or transposed. This is of importance when designing check lists or deciding on the contents of an RT message. As anyone who has received a complicated departure clearance is aware, much of the information cannot be memorised, but must be written down.

Short-term memory:

Information will be lost in 10 to 20 seconds unless actively rehearsed.

Short term memory is also highly sensitive to interruption and distraction. For example, if a frequency is passed to a pilot and before he selects it an interruption or distraction occurs, the information is immediately lost.

Methods of Increasing Short-Term Memory Capacity.

There are two main tools which may be used to increase the capacity of Short-term memory:

- **Chunking**. We can expand the number of items retained in our short-term memory by a system of chunking any related material. Chunking works best when the individual is familiar with the information. For instance, a typical British telephone number may contain ten or more digits e.g. 04235426565 but can be chunked to:

  04235 426 565

  Now that the digits have been chunked, there are only three items to be held. Telephone directories in France utilise this method of chunking (e.g. 02-13-24-16-33).

- **Association**. Association is a technique used by many when remembering lists of items. A picture or word association is imagined and attached to each item on the list.

Typical examples of items stored in the short-term memory, during a flight, would be: radio frequencies, heights and altimeter sub-scale settings prior to selection, Air Traffic Control instructions, and verbal responses to check lists, prior to their execution.

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LONG-TERM MEMORY.

Introduction.

If the information in the short-term memory is rehearsed, it will then be transferred into the long-term memory. It is believed that information is stored in the long- term memory for an unlimited time period, although frequently there can be retrieval problems. One major disadvantage of long-term memory is the time that it takes to access information from it.

The long-term memory can be divided into three types:

- **Semantic memory**.
- **Episodic memory**.
- **Procedural memory (Motor Programmes)**.

Semantic Memory.

Semantic memory stores general knowledge of the world, storing answers to such questions as: Are fish animals? Do birds fly? Do cars have wheels? It is believed that semantic memory holds concepts that are represented in a dense network of associations. Language is also held in semantic memory. It is generally thought that once information has entered semantic memory it is never lost. It is certainly more accurate than episodic memory. When we are unable to remember a word, it is often because we are unable to find where the item is stored, not because it has been lost from the store.

Episodic Memory.

Episodic Memory is a memory of events or episodes in our life: a particular flight, meeting, or incident. However, episodic memory is prone to change along the lines of how we would have liked an event to have occurred, rather than how it really occurred.

Figure 8.7 Episodic Memory.

Procedural Memory (Motor Programmes).

Although some experts in the field of Information Processing agree that long-term memory consists of only episodic and semantic memories, there are those who include motor programmes or skills as a third constituent of long-term memory.

PERCEPTION.

Perception gives us our mental model of the world.

Perception involves the converting of sensory information into a meaningful structure. For example, a pattern of vibrations in the air becomes recognised as sound carrying a particular message.

The percept (what we perceive) is not a complete representation of the information in the sensory store, but an immediate interpretation of it. For example, read the words in the yellow triangle *(Figure 8.8)* out loud:

The words actually read: “a bird in the the hand”. Most people will read the sign incorrectly the first time, missing out the second “the”. The reason for this, in this case, is simple. The words form the beginning of a well known phrase and, having read the first three lines of the triangle, the reader believes he knows what is coming next and may automatically pass on to the last word to confirm his belief, missing out the extra “the”.

Figure 8.8.

It follows that the sensory information that we expect to receive is more easily perceived and integrated than totally unexpected information. This should serve as a warning to pilots. Anticipating information, for instance in a particular standard radio message, that sounds like a message a pilot has heard many times before, may cause him to miss a small but important piece of information or instruction.

It is true that we can perceive only something that we can conceive. It is also true that we perceive only a fraction of the information reaching our senses at any moment. Therein lies the importance of the attention mechanism in our model in *Figure 8.1*. The process of perception is greatly assisted by our ability to form mental and three-dimensional visual models of what we are perceiving.

Consider the following text.

Aoccdrnig to a rscheearch at an Elingsh uinervtisy, it deosn’t mttaer in what oredr the ltteers in a word are, the olny iprmoetnt tihng is that frist and lsat ltteer is at the rghit pclae. The rset can be a toatl mses and you can still raed it wouthit porbelms. This is bcuseae we do not raed ervey lteter by itslef but the word as a wlohe.

We perceive the meaning of all the words in the text because we have already formed models - which are stored in our long term memory - of the individual words. So, even though the letters are jumbled, all except the first and the last letters of the word, that is, we recognise the words instantly.

Funnelled Perception.

Perception of a situation can differ depending upon the point of view from which the process of perception begins. Consider two men walking through some woods when they come across a family group having a picnic *(See Figure 8.9)*. The first man may perceive the overall picture of a family enjoying themselves together in the open air, whereas his companion may, first of all, perceive details of the scene, rather than the whole picture. The second man may perceive the contrast between the red

Figure 8.9 Funnelled Perception.

of one woman's top and the white and blue clothing of the baby she is holding, or, perhaps, the picnic basket that the family is using.

It is possible, of course, that after a few seconds both observers will perceive the same picture. The first man may narrow his overall perception to include the detail of the scene, and the second may expand his perception to include the generalities. So, the initial perception that the two men had of the same scene was entirely different, but each man eventually perceived all the available information. This process is called funnelled perception.

ATTENTION.

Introduction.

Attention is the deliberate devotion of the cognitive resources to a specific item. A person must be alert to be attentive. But being alert is not sufficient guarantee that attention will be paid to the right item at the right time.

Choice of Item.

Due to the limitations of the Central Decision Maker (the **brain**), we are generally unable to pay attention to a number of different items at any one time. Although attention can move very quickly from item to item, it can only deal with one item at a time. Consequently, there is a need for the pilot, consciously, to prioritise between items of information; *(See Figure 8.10)*.

Figure 8.10 The pilot constantly prioritises information.

Attention Mechanism.

The attention mechanism is required because of the following two potentially limiting stages in processing information:

- There is a limit to the number of items that can be held or maintained in the short-term memory.
- Our channel capacity is limited. We cannot devote conscious thought to, or simultaneously attend to, all of the stimuli entering our senses.

This limited channel capacity means that there must be a mechanism at an early stage of the perception process which allows us to select those stimuli which will be perceived consciously, and used as a basis for our consideration and our decisions, and to reject other stimuli. Some stimuli are extremely efficient for getting our attention. For example, the cocktail party effect, which relates to our hearing our own name mentioned in a background of many conversations.

For a pilot, flying his aircraft, an equivalent phenomenon may be hearing his RT call-sign among a lot of radio chatter, or detecting a smell of burning in the cockpit. Either of these two stimuli would focus a pilot's attention on the need to obtain more information.

Figure 8.11 A pilot will hear his RT call-sign among the radio chatter.

Types of Attention.

Attention is the process of directing and concentrating sensory resources to enhance perception, performance and mental experience. Attention has three basic characteristics:

- It improves mental processing.
- It requires effort.
- It is limited.

There are two types of attention:

- **Selective Attention**, when inputs are sampled continually to decide their relevance to the task at hand, a pilot's call-sign being particularly attention-getting in the air.

- **Divided Attention**, when our central decision making channel can divide its resources between a number of tasks. A pilot flying a visual approach *(Figure 8.12)* will be dividing his attention between looking ahead to maintain his approach path, and checking his flight instruments for air speed, height, engine power etc.

Although we might think that the pilot is working on a number of tasks simultaneously, in reality the Central Decision Maker is spending a fraction of every second on a different, separate problem, in turn.

Figure 8.12 Divided Attention.

Lack of Attention.

It is important to remember that the mind is always paying attention to something - except during sleep. Therefore, the major danger for pilots is the poor management of attention; that is to say, paying attention to the wrong item from a number of items of rival priority.

Stress, Attention, and Performance.

This subject has been covered in a previous chapter. But, briefly, stress can have a significant effect on attention, especially during times of low and high arousal. Our limited ability to process information has implications for the level of performance we are able to achieve when subject to various levels of stress. The way in which performance is affected by arousal can be shown by the Performance/Arousal Curve. *See Figure 8.13*.

Low Arousal.

At times, such as in the cruise, when a pilot is on track, sure of his position, on time, and on heading, a pilot may feel so satisfied with the progress of his flight that he enters into a state of low arousal. In this state, the pilot's attention may wander with the result that important information that is presented to him, suddenly and unexpectedly, is either missed or misinterpreted. Continually monitoring airspeed, altitude, heading, location and timing in a systematic way is a method of addressing low arousal.

In a state of low arousal, a pilot's attention may wander, and he may miss vital information.

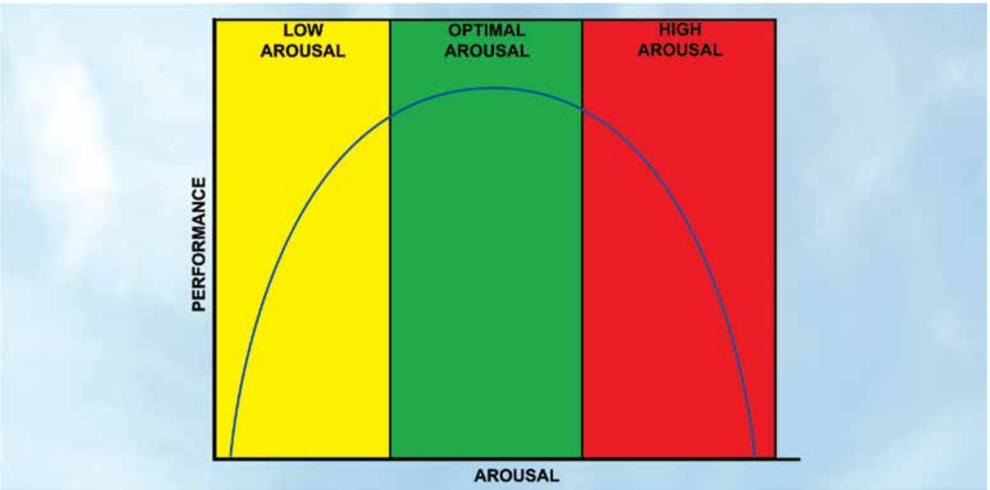

Figure 8.13 Performance/Arousal Curve.

Optimum Arousal.

If a pilot is working normally, updating timings, checking speed, altitude, heading, location etc, he is optimally aroused and at his most efficient.

High Arousal Overload.

At times of high arousal, when the pilot is overloaded because of the limited channel capacity of the brain, there is a real danger of his attention becoming so narrowed that important information is disregarded. Indeed, if overloaded, the attention mechanism may even reject vital information.

Overload can be of two types:

- **Qualitative Overload.**
  The information is perceived to be beyond the pilot's attention capacity and the task too difficult.

- **Quantitative Overload.**
  There are just too many responses to be made in the time available.

Symptoms of Overload.

The symptoms of overload will vary from individual to individual. Among the most common are:

- A sharp degradation of performance.
- Funnelling of attention or focus.
- Regression, where the correct actions are forgotten and procedures learnt in the past are substituted.
- Mental blocking, where it becomes impossible to review or even to consider other solutions.
- Mood swings, some individuals becoming aggressive towards others.
- Restlessness.
- Panic.

HUMAN ERROR.

Studies of the rate of occurrence of human error during the performance of a simple and repetitive task show that an error can normally be expected to occur once in about 100 actions. For example, if an individual is given the task of inserting 100 letters individually into 100 envelopes and subsequently sealing the envelopes, there would be a strong possibility that one envelope would be sealed without the insertion of a letter.

An error rate of this order is built into the human system and can increase rapidly when stress, fatigue or low morale are added factors. But it has been demonstrated that, with practice, human reliability can be improved by several orders of magnitude.

General Errors.

Error is a generic term which describes all those occasions on which a series of mental or physical activities do not achieve their intended effect.

Human error may range from a mere slip of the tongue to error which can cause loss of human life in disasters such as the Tenerife runway collision in 1977, the Bhopal methyl isocyanate tragedy in 1984, or the Challenger and Chernobyl catastrophes in 1986.

Error Generation.

*Errors tend to be cumulative, building an **error chain**.*

Although isolated errors which may occur have neither consequence for, nor influence on, any further events, errors in general tend to be cumulative (that is, one error leads to a second which, in turn, leads to a third and so on). This phenomenon is commonly known as an **error chain**.

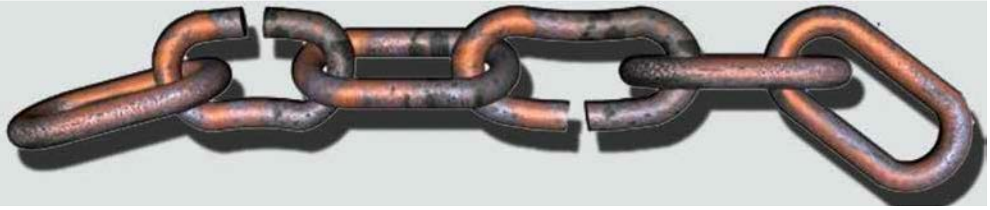

Figure 8.14 Errors are often cumulative and give rise to an error chain.

A simple example of an **isolated error** is that of a gardener pulling out a young plant from a flower bed, mistaking it for a weed. A **cumulative error** would, for example,

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be that of an engineer issuing an incorrect aircraft maintenance procedure which results in a series of accidents.

THE LEARNING PROCESS.

Introduction.

We have already discussed the role of the learning process in initially acquiring skills and in the further development of skills. However, the learning process also allows us to acquire knowledge through the mental acquisition and retention of data.

Figure 8.15 The Learning Process.

Types of Learning.

There follows a list of the most common types of learning.

Classical/Operant Conditioning, which is the behaviouristic approach of Pavlov where the recipient is taught through principally physiological responses. An example of this type of learning having taken place is an experienced pilot's reaction to a fire warning.

Insight, where data is intellectually and cognitively understood and is retained; for example, a pilot selecting radio and navigation aid frequencies.

Observation & Imitation, where data from an outside source is replicated; for example, a student pilot following-through on the controls as an instructor flies an approach and then flying the approach, himself, shortly afterwards.

Learning from Experience, sometimes called learning from our mistakes.

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Quality of Learning.

Some of the factors affecting the quality of learning are:

- The intellectual capacity of the learner, or recipient of data.
- The quality of communication between transmitter and recipient.
- The applicability of the data.
- The motivation of both the transmitter and the recipient.
- Over-learning. Over-learning is learning beyond the degree required to perform to the minimum acceptable level. Over-learning not only improves the chances of data recall, but also makes the performance of the task learnt more resistant to stress.

Retention of Learning.

Information **retention** can be increased by the use of:

- Mnemonics (e.g. for pilot checks such as HASELL, FEFL or FREDA).
- Memory Training.

  Among the methods of improving memory retention commonly used are:

  i) Word, phrase or object association.

  ii) Chunking.

  iii) Repetition.

  iv) Revision.

  v) Research.

Motivation.

It is possible to learn without **motivation**; however, the learning process is vastly improved when the learner is highly motivated, and good performance is rarely achieved without it.

Experience.

We all have the ability to learn from our experiences and mistakes, and from those of others.

Response.

Any action that a human being initiates will normally cause a detectable change in circumstances which, in turn, will promote feedback which may modify the original action taken. For example, a pilot attempting to select a desired angle of bank will receive feedback from the natural or artificial horizon. From the perceived rate of roll, the pilot may increase or decrease lateral pressure on the control column, and, when the desired angle of bank is reached, the visual feedback will cause the pilot to return the control column to the neutral position.

When there is pressure on a human being to make a rapid response, to an emergency, there are a number of factors to be borne in mind.

- There will frequently be a trade-off between speed and accuracy of response. A delay in response, in some situations, could be dangerous (e.g. engine failure after take-off). On the other hand, there may also be pressure on a pilot to make a response before sufficient information has been processed.

- A high arousal level leads to faster but less accurate responses.

- Auditory stimuli (noises) are more likely to attract attention than visual stimuli, but they are also more likely to be responded to in error.

- As a human being ages, from 20 to 60 years, responses become slower but may become more accurate.

Response Error (Error of Commission).

If a person expects a stimulus and prepares a response to it, in advance, he will respond quickly if the expected stimulus occurs. If, however, an unexpected stimulus occurs he will, under pressure, very likely make the prepared response even if that response is not appropriate. This is called error of commission.

For example, a pilot may have noticed engine instrument readings showing temperatures and pressures approaching their operating limits. He will, therefore, mentally prepare to carry out the engine shut down drill if the limits are exceeded. Any subsequent stimulus, perhaps an unexpected variation in engine rpm, may then be sufficient to prompt the pilot to shut down the engine.

Response Times.

Response or reaction time is the time interval between the onset of a given signal and the production of a response to that signal.

In the simplest case, such as pushing a button when a light illuminates, the reaction time is about 0.2 seconds. If we complicate the task by having two lights and two buttons, the reaction time will increase, because the brain (the central decision maker) has more information to process.

In flying, reaction times are important, but, in general it is more important that a pilot should make the correct response, rather than a fast response.

COGNITION IN FLYING - ILLUSION.

Introduction.

Cognition is a scientific word which simply means knowing, perceiving or discovering.

Pilots must recognise the reality of their environment if they are to fly safely and efficiently. But flight can put the pilot into an environment which distorts the cognitive senses, especially the sense of vision. In addition, the pilot’s changed perspective on the world, in flight, can result in information being presented which is outside his expectations, and, therefore, likely to be misinterpreted. *(See Figure 8.16)*.

Figure 8.16 A pilot's perspective on the outside world may lead to misinterpretation of information.

Human beings use mental models as references to make sense of the world and to guide their actions. Mental models, however, can be incomplete and, thus, faulty. The difference between what a person perceives and the reality he is looking at is called illusion.

Objects seen from the air often look quite different from when they are viewed on the ground. The pilot, therefore, should be aware of the possibility that he may misinterpret visual information received.

Illusions are particularly dangerous in aviation, as a pilot normally considers visual inputs to be the most reliable of all the information that his senses perceive.

The pilot often has to interpret patterns of lines on the ground, especially in terms of runway aspect and distances, when flying an approach. But, as the following figures illustrate, a pilot's interpretations of visual information may not always be correct.

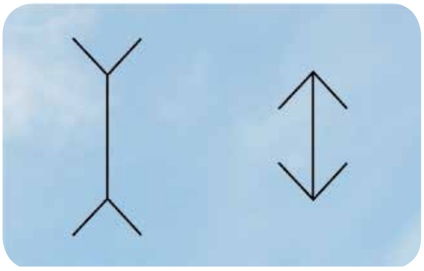

Figure 8.17.

Figure 8.18.

In *Figure 8.17*, the figure with the out-going fins appears to contain a longer line than the other, although both lines are exactly the same length. The junction of two roads or railway lines, the alignment of valleys, or even a small runway running into the corner of a field, where hedges meet, can give a false impression of runway length.

In *Figure 8.18,* the upper of the two horizontal lines appears the longer; but both lines, in fact, are the same length.

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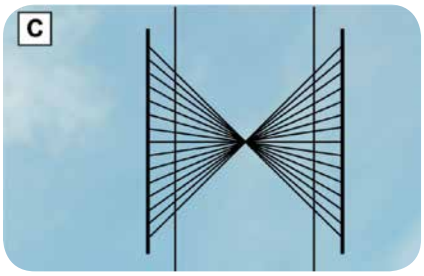

Figure 8.19.

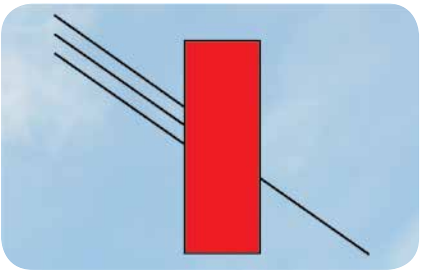

Figure 8.20.

In *Figure 8.19,* the vertical lines appear curved, but they are straight.

Ask yourself which of the three lines in *Figure 8.20* passes through the red block. It is, in fact, the middle line.

Illusion, then, is a powerful trickster. For instance, the two illustrations shown below, in *Figure 8.21*, are able to be drawn, but neither could exist in reality.

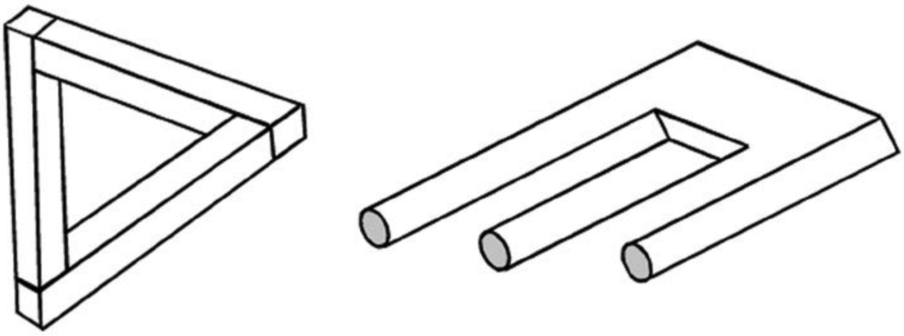

Figure 8.21.

Atmospheric Perspective.

Illusions in flying are often associated with situations that a pilot meets infrequently. For example, the pilot who has done most of his flying in relatively polluted air may have learned to use atmospheric perspective as a good cue to range. If the pilot then operates in a very clear atmosphere, he may judge distant objects, because of their clarity, to be much closer than they actually are. A number of accidents have occurred in polar regions when pilots flying in very clear conditions have miscalculated the distance to a landing ground situated close to a landmark.

Figure 8.22 Atmospheric conditions can give a false impression of distance to a landmark.

Illusions When Taxying - Relative Movement.

Even on the ground we are not free of illusions. A vehicle moving slowly away from the aircraft may cause the illusion to the pilot that it is his aircraft which is moving. (Most of us have had the experience of sitting in a stationary train at a station when an adjacent train pulls away, causing the illusion that it is our train which is moving!)

Blowing snow may give a false impression of relative speed. When an aircraft is taxying with a tailwind, the snow may appear to be falling vertically, causing the illusion that the aircraft has stopped, when, in fact, the aircraft may still be moving. Application of the parking brake in these circumstances could have serious consequences. Alternatively, the aircraft could creep forward, colliding with an obstacle, because the pilot believed the aircraft to be at a standstill.

When taxying into a headwind the blowing snow will give the illusion that the aircraft is taxying faster than it is. When taxying, therefore, the pilot must look out of the side cockpit panels in order to gain an accurate assessment of taxying speed.

Illusions in the Cruise.

Autokinesis.

Staring at an isolated and stationary light when other visual references are inadequate or absent may cause autokinetic movements of the eyes.
Autokinesis gives rise to the illusion that the light is moving and can lead the pilot to believe that a single star is another aircraft. The autokinesis illusion is created by small movements of the eye ignored by the brain and interpreted as motion of the object. Numerous cases have been reported of mistaken identity of lights. These illusions of autokinesis can be avoided by shifting the gaze to eliminate staring. Normal visual scanning should be sufficient to prevent autokinesis.

Figure 8.23 Autokinesis can be caused by staring at a single light.

Vertical Separation.

A common problem in flight is the evaluation of the relative altitude of approaching aircraft and the assessment of a potential collision risk.

At a distance, an aircraft may appear to be at a higher level but may eventually pass below the observer.

If you perceive there is a collision risk, always take appropriate action.

Figure 8.24 Vertical Separation is difficult to judge.

False Horizon.

Sloping cloud, if widespread enough, may cause a pilot flying above the cloud to perceive a false horizon. The pilot, in this situation, may get the impression that he is flying one wing low, even though the aircraft's wings are level. Frequent checks of the artificial horizon - using a normal scanning pattern (look out, attitude, instruments) - should prevent a pilot committing this error.

Failure to scan his instruments regularly could lead to the pilot mistaking the sloping cloud layer as the "true" horizon, levelling the aircraft's wings on this misperceived reference and, as a consequence, flying with bank applied, and out of balance.

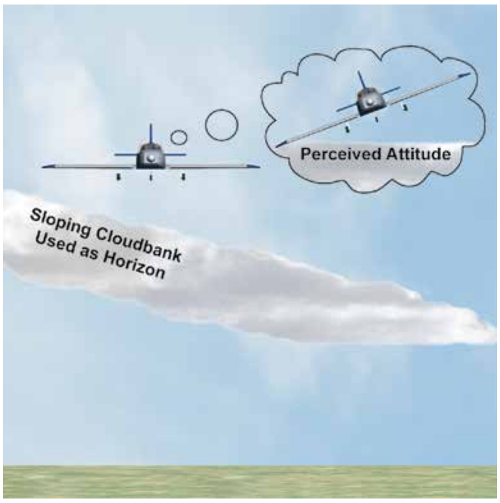

Figure 8.25 False Horizon.

Beware not to use sloping cloud tops as your visual horizon.

Illusions on Take-Off and Landing.

After take-off or on the approach to land, outside references may cause the pilot to misinterpret visual stimuli. Some examples of outside references which may deceive a pilot in these two critical phases of flight are listed here.

Immediately after take-off, a false horizon may be perceived when surface lights are confused with stars.

Over water, the lights of fishing boats may be mistaken for stars and the flight path adjusted inappropriately.

In hilly terrain, it is possible that, when emerging from low cloud or mist on take-off, lights on the ground will be mistaken for stars and the flight path adjusted to a lower and dangerous profile.

Gently sloping terrain may create an illusion affecting a pilot's perception of his flight path, at any time when flying visually at low level.

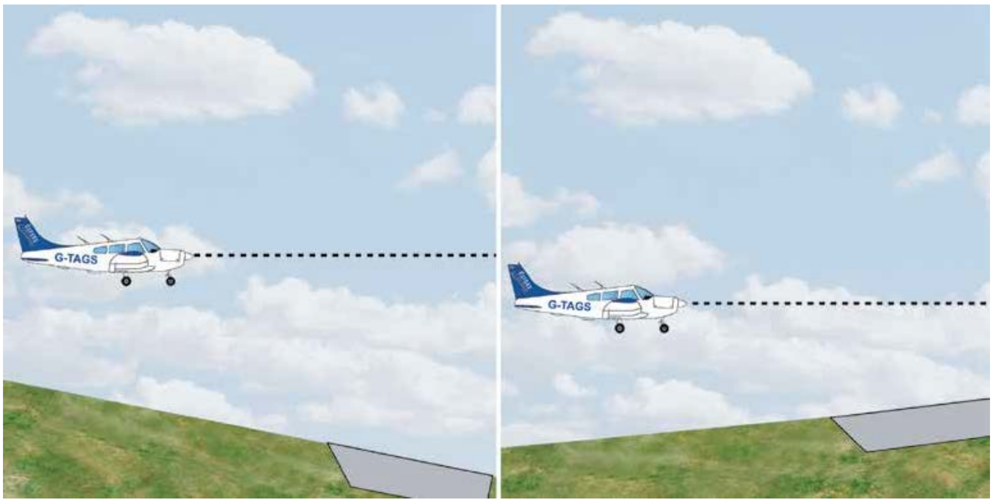

Figure 8.26 Sloping terrain on approach may confuse a pilot's perception of height.

After take-off or on approach, if the ground slopes down, an illusion of excessive height may be created. Upwards sloping terrain would have the reverse effect. *(See Figure 8.26.)*

JUDGEMENT OF THE APPROACH.

During your flying training, you will have learnt to recognise the way the runway looks when you are on the correct approach path. Your instructor will have taught you how to fly a correct approach based on your judgement of runway aspect. This aspect will look something like that depicted in *Figure 8.27,* when you are 300 to 400 feet above runway level, established on the approach path.

Figure 8.27 Correctly positioned for the approach to a level runway.

Now, most airfields at which you fly an approach are built on level ground, and most runways are of similar width. Consequently, wherever you fly an approach, you should attempt to line yourself up with the runway in such a way as to give yourself the view of the approach to which you are accustomed, and which you know to be correct.

At large aerodromes, you may find that there are Precision Approach Path Indicators to aid the pilot. Using these aids may lead you to fly a flatter approach than you are used to at a club airfield, but you can be sure that the information that the VASIs and PAPIs are giving you is safe.

On approaches to most club airfields, however, you will be relying on the runway aspect method learnt during your flying training. In doing so, you should be aware that, if the runway is sloped, the aspect which it presents to you may deceive you, so that your perception of your approach angle will be faulty.

Upward Sloping Runway.

When you are approaching a runway which slopes upwards, away from you, as depicted in *Figure 8.28a*, even though you are correctly positioned on the approach path, the runway will appear longer and give you the impression that you are high on the approach. The pilot's view of the runway, in this case, is shown in *Figure 8.28b*.

An upsloping runway can lead a pilot to fly a flatter approach than intended, and get too low on the approach.

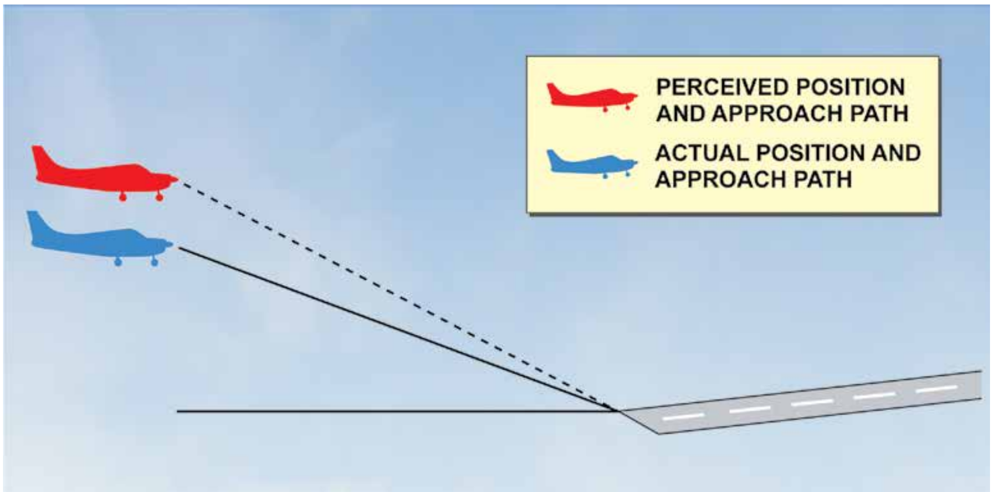

Figure 8.28a Upward Sloping Runway.

With this view, you may want to adjust your approach path to fly a flatter approach. If you follow that instinct, the danger is that you will fly a shallower approach than you intended and get too low on the approach. If, however, you are aware that the runway is sloping upwards, you can avoid this error.

Figure 8.28b. With an up-sloping runway, the pilot who is correctly positioned on the approach gets the impression of being too high.

Downward Sloping Runway.

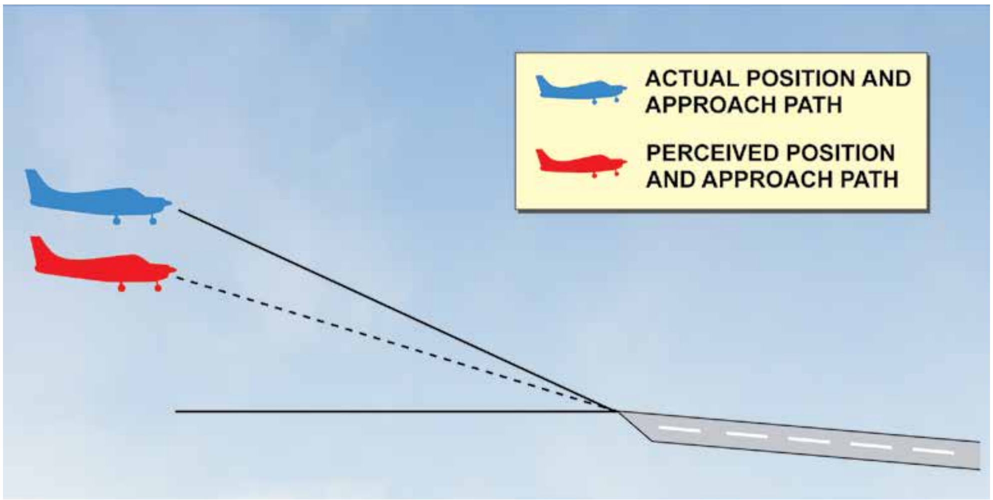

Figure 8.29a Downward Sloping Runway.

A downsloping runway can lead a pilot to fly a steeper approach than intended, and get too high on the approach.

When you are approaching a runway which slopes downwards, away from you, as depicted in *Figure 8.29a*, even though you are correctly positioned on the approach path, the runway will appear shorter and give you the impression that you are low on the approach (*See Figure 8.29b).*

With this view, you may want to adjust your approach path to fly a steeper approach. If you follow that instinct, the danger is that you will fly a steeper approach than you intended and get too high on the approach. If, however, you are aware that the runway is sloping downwards, you can avoid this error.

Figure 8.29b With a downwards-sloping runway, the pilot who is correctly positioned on the approach gets the impression of being too low.

Width of Runways.

Approaching a narrower than usual runway may lead a pilot to fly a lower than normal approach, with the possibility of rounding out too late, or landing short of the runway.

The width of the runway may also cause incorrect height judgements on the final approach. A pilot used to a standard width runway of 150ft (46m) may, when approaching an unfamiliar airfield with a narrow runway, judge he is too high on the approach and, therefore, round out too low, causing the aircraft to come into contact with the runway sooner than the pilot expected. This situation would result in a heavy landing. However, if the pilot believes he is too high, he may even be led to losing height too rapidly and land short of the runway.

At an airfield with a wider runway than the pilot is used to, the tendency will be for the pilot to round out too high on the approach, in an attempt to match the visual stimuli to his expectation. Again, this may lead to a heavy landing, as the aircraft stalls into the runway from a height of several feet, or more. Alternatively, the pilot may land too far down the runway.

Size of Runways.

A runway which is shorter than the ones a pilot is used to will appear to be further away than it is in reality. A runway which is longer than the ones a pilot is used to will appear to be closer than it actually is.

The Black Hole Effect (The Kraft Illusion).

When approaching an airfield at night with only the airfield lights visible at a distance and no town or street lights in the pilot's visual field, the pilot perceives an apparent black hole with the airfield in the middle. In this situation, he gets no information on the terrain surrounding the airfield. This absence of visual cues leads to an illusion called the black hole **effect**. This illusion gives the pilot the impression that the aircraft is too high. As a result, the approach path may be flown at too shallow an angle, with the danger that the aircraft will touch down short of the runway (*See Figure 8.30).*

Figure 8.30 The Black Hole Effect (The Kraft Illusion).

OTHER MISPERCEPTIONS.

Water and Height Judgement.

Flying over a smooth water surface makes it extremely difficult to judge height due to the lack of visual cues indicating surface features.

On hazy days, a pilot flying low over water may not be able to perceive the horizon line separating sky and water. These conditions have been known to lead pilots to fly into the water under full control of their aircraft.

Snow Coverage.

Not only does snow lead to false height judgements, but, because of the absence of terrain features, it is also difficult to discern where the surface ends and the sky begins. Such conditions are called white out. White out makes navigation difficult and degrades a pilot's depth and slope perception. Navigation difficulties in white out conditions arise from the pilot's inability to distinguish ground features. The landscape appears to be a flat, smooth plane of white.

Fog/Pollution and Low Visibility.

As a result of fog or pollution, runway lights appear dim giving the impression that the runway is further away than it is. This phenomenon also gives rise to steeper approaches than normal.

Runway Lights.

The intensity of runway lights will also lead to errors. Their brightness or dimness will, respectively, give the false impression of the runway being either closer or more distant than it is in reality.

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CONCLUSION.

The principal aim of this chapter has been to teach you that our brain, the **central decision maker**, does not always perceive the reality of a situation, because it can misinterpret the image seen by the eyes. However, if a pilot understands the circumstances within the real world, and the configuration of objects within the real world, which lead to the illusions that can be misinterpreted by the brain, he should be able to avoid being led into danger by the most common of those illusions.

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Representative PPL - type questions to test your theoretical knowledge of The Information Process.

1. Unconditioned reflexes are:

   a. Those which can be learned
   b. Those that may be improved by repetition
   c. Those which are instinctive
   d. Those that are required by the check list

2. Perception is one of the most important aspects of information processing because:

   a. Sensory information is modelled into a meaningful structure
   b. Good judgements and decisions are made at this stage
   c. Corrective actions and responses are carried out at this stage
   d. It incorporates selective, divided and focused attention

3. “Chunking” is:

   a. The grouping of check list items to reduce turn round time
   b. A bizarre method of word association technique
   c. A method of increasing the number of unrelated items held in working memory
   d. The associative phase of learning a skill

4. The three parts of long-term memory are classified as:

   a. Ultra short, short and working
   b. Selective, divided and focused
   c. Static, dynamic and motor
   d. Semantic, episodic and procedural

5. An Illusion is:

   a. A deliberate modification of the truth to catch out the unwary pilot
   b. When perception is not the same as the real world
   c. The difference between divided and selective attention
   d. A condition arising when deprived of visual or auditory stimuli

6. If a pilot flies a visual approach to a runway which has a pronounced upward slope of which he is unaware, what will be the likely result?

   a. The pilot will fly an approach which is shallower than intended, leading to the possibility of undershooting.
   b. The pilot will fly an approach which is steeper than intended, leading to the possibility of overshooting.
   c. The pilot will fly an approach which is shallower than intended, leading to the possibility of overshooting
   d. The pilot will fly an approach which is steeper than intended, leading to the possibility of undershooting.

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7. If a pilot flies a visual approach to a runway which has a pronounced downward slope of which he is unaware, what will be the likely result?

   a. The pilot will fly an approach which is shallower than intended, leading to the possibility of undershooting.
   b. The pilot will fly an approach which is steeper than intended, leading to the possibility of overshooting.
   c. The pilot will fly an approach which is shallower than intended, leading to the possibility of overshooting
   d. The pilot will fly an approach which is steeper than intended, leading to the possibility of undershooting.

8. If a pilot flies a visual approach to a runway which is wider than the runway he is used to, what will be the likely result?

   a. The pilot will fly an approach which is higher than intended with the danger that he will round out too late, or undershoot the runway.
   b. The pilot will fly an approach which is lower than intended with the danger that he will round out too late, or undershoot the runway.
   c. The pilot will fly an approach which is lower than intended with the danger that he will round out too late, or overshoot the runway.
   d. The pilot will fly an approach which is higher than intended with the danger that he will round out too soon, or overshoot the runway.

9. If a pilot is on the final approach to a runway which is narrower than he expects, what will be the most likely result?

   a. The pilot will be led to fly a higher approach than normal, with the danger of rounding out too soon, or overshooting the runway.
   b. The pilot will fly a lower approach than normal, with the danger of rounding out too soon, or overshooting the runway.
   c. The pilot will fly a lower approach than normal, with the danger of rounding out too late, or undershooting the runway.
   d. The pilot will be led to fly a higher approach than normal, and be forced to go around.

10. If a pilot is flying above a layer of stratus cloud with a sloping upper surface, how is the pilot most likely to misperceive the visual image?

   a. The pilot may mistake the slope as a lowering cloud base, and divert to an alternate airfield.
   b. The pilot may feel that he is climbing and initiate a descent.
   c. The pilot may mistake the upper surface of the cloud layer as the “true” horizon and apply bank as he selects an attitude which puts the aircraft’s wings parallel to the cloud surface.
   d. The pilot may feel that he is descending and initiate a climb.

11. Hazy conditions may lead a pilot to perceive:

    a. Objects outside the aircraft as being further away than they actually are
    b. Objects outside the aircraft as being closer than they actually are
    c. Objects outside the aircraft as being more numerous than they actually are
    d. Objects outside the aircraft in exactly the same way as in conditions of good visibility

12. Approaching a runway at night where only the runway lights are visible, with no lights to indicate the nature of the surrounding terrain may result in the pilot:

    a. Flying too high an approach and overshooting the runway
    b. Flying too high an approach and undershooting the runway
    c. Flying too low an approach and overshooting the runway
    d. Flying too low an approach and undershooting the runway

13. How will a pilot perceive a runway to which he is flying an approach, but which is smaller than the runways he his used to?

    a. The runway will appear nearer than it is in reality.
    b. The runway will appear further away than it is in reality.
    c. The pilot will get the impression that he is low and close.
    d. The pilot will perceive no difference between this runway and the ones he is used to.

14. How will a pilot perceive a runway to which he is flying an approach, but which is bigger than the runways he his used to?

    a. The runway will appear nearer than it is in reality.
    b. The runway will appear further away than it is in reality.
    c. The pilot will get the impression that he is high and distant.
    d. The pilot will perceive no difference between this runway and the ones he is used to.

Question	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Answer												

13	**14**

The answers to these questions can be found at the end of this book.

CHAPTER 9
JUDGEMENT AND DECISION MAKING

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INTRODUCTION.

In previous chapters we have learnt that a human being perceives the majority of external stimuli through his visual, auditory and vestibular senses. Some of this information is filtered out or compartmentalized by the brain, but, in general, stimuli are then analysed within a mental process. This analysis usually leads to the human being reaching a decision based on his judgement, and, then, initiating an appropriate action. The faculty of judgement is based on such things as previous experience, values, beliefs, etc. The whole process may be referred to as judgement and decision making.

Be aware of the crucial importance that sound judgement and decision making have in the safe conduct of a flight.

FACTORS AFFECTING DECISION MAKING.

General.

For a pilot to perform optimally at the controls of an aircraft, in terms of judgement and decision making, he must possess suitable levels of skill, knowledge and experience to deal with the situation he finds himself in, whatever the phase of flight, whatever the weather, and whatever the air traffic situation.

A pilot's powers of judgement and decision making are also, of course, affected by his emotional state, tiredness, fatigue, his state of physical and mental health, and his personal motivation.

The important thing for any pilot to be permanently aware of is the crucial role that judgement and decision making play in the safe conduct of all the flights that he will ever make. Making the wrong decision and exercising bad judgement can lead to a hazardous air or ground situation developing which, at best, is embarrassing for the pilot and inconvenient for other users of the air, and, at worst, can involve accident and tragedy.

Mental Overload and Under-load.

In addition to the factors affecting judgement and decision making mentioned above, the degree of a pilot's mental workload, in any given air or ground situation, greatly affects his ability to think clearly and to act logically. Pilots carry out their piloting tasks most effectively if they are neither overloaded nor under-loaded. Every human being needs some kind of stimulus to function effectively. Psychologically speaking, the level of stimulus that a person experiences may be linked to the states of being under or over-loaded, through the term arousal. Most pilots are driven to function effectively by an intense desire to fly. But complacency on a routine flight can possibly lead to a pilot being under-loaded or, to use a related expression, under-aroused. *(See Figure 9.1)*

Such a situation may lead him to commit errors through carelessness and inattention. Conversely, if a pilot is put under pressure through finding himself in deteriorating weather conditions or an unexpectedly busy air traffic environment, he may become overloaded or over-aroused. *(See Figure 9.2)*

In this situation, too, his judgement and decision-making ability is likely to deteriorate.

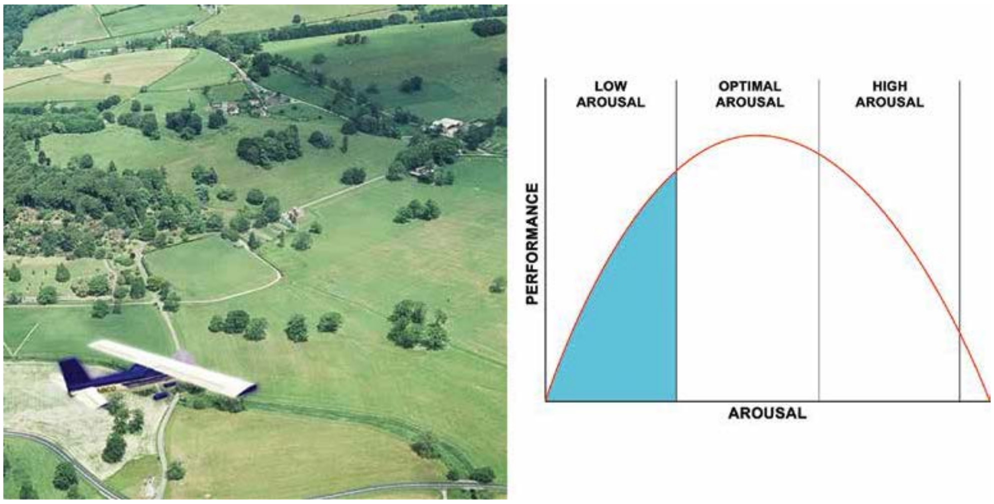

Figure 9.1 Routine flying may lead to under-arousal and inattentiveness.

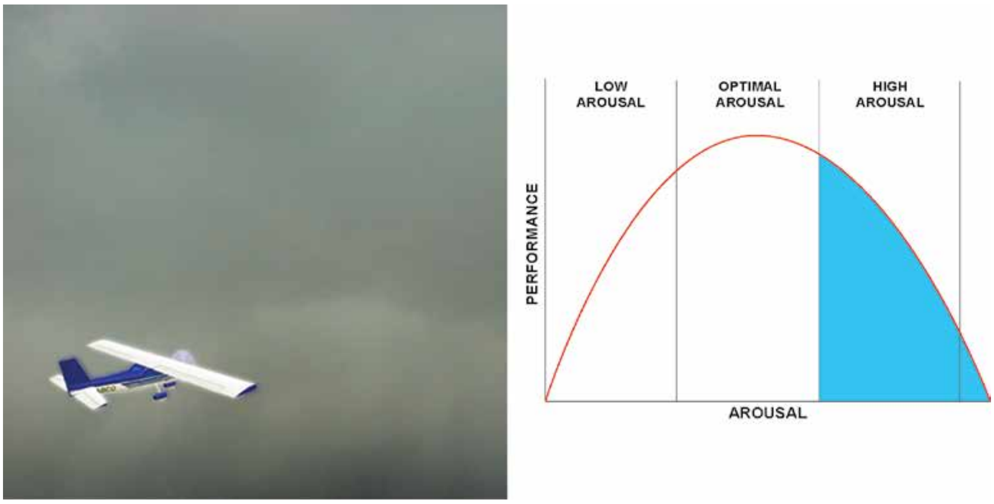

Figure 9.2 Flying in deteriorating weather conditions may lead to performance degradation through mental overload or overarousal.

Pilots can avoid performance degradation through under-arousal by maintaining strong personal motivation, maintaining a healthy respect for the hazards of flying traditionally associated with inattentiveness, and by ensuring that they have set themselves a measurable objective for every flight.

The risk of performance degradation through mental overload or over-arousal can be lessened by thorough and systematic pre-flight planning. *(See Figure 9.3)*

Figure 9.3 The risk of performance degradation through mental overload or over-arousal can be lessened by thorough and systematic pre-flight planning.

THE IMPORTANCE OF GOOD DECISION-MAKING.

Making good decisions based on a sound assessment of the air or ground situation is one of the most important aspects of piloting an aircraft.

The risk of poor performance in the air can be lessened by thorough and systematic pre-flight planning.

A low-experience pilot may find it difficult to make correct decisions in a timely manner, but, with training, practice and experience, he will find that effective decision-making gets easier as routine piloting skills become more and more second nature to him. A pilot will also find decision-making easier when finding himself in situations he has already experienced.

Talking to one's instructor and other appropriately experienced pilots about all aspects of piloting is an excellent way to supplement your own experience.

When flying with another pilot of similar qualifications and experience, it is possible to increase the chance of good decisions being made in the air by discussing potential problem issues before getting airborne.

The following guidelines to the decision-making process, in the event of a problem arising when airborne, may be helpful:

- Continually evaluate all relevant information from your eyes, instruments and ears.
- Recognise the real situation, not the one you would like to be in.
- Identify the problem.
- Making allowances for personal skill level, experience, environmental factors such as weather and daylight, the aircraft's performance and time available, consider solutions to the problem.
- Weigh up the risks.
- Make the decision.

- Carry out the necessary action.
- Monitor progress and, if necessary, re-evaluate your decision.

QUESTIONING DECISIONS MADE BY OTHERS.

When flying with a very experienced pilot who, in your judgement, has taken a dangerous decision, you should inform him immediately of your doubts.

Modern studies of the role played by human factors in aircraft accidents have identified numerous cases of an inexperienced crew member, on a multi-crew flight deck, failing to question the action of a more experienced member of the crew, usually the aircraft captain, even when the inexperienced crew member has recognised, or suspected, that things are going badly wrong. Tragically, there have been cases of fatal accidents where a junior crew member, who clearly recognised the danger that was being entered into, failed to express his concerns.

If, as an inexperienced pilot, you are flying with someone of greater experience, and you see him do something you consider to be dangerous, you must immediately question his course of action.

RISK.

In reaching a decision about the desirability and effectiveness of a proposed action, it is often a good idea to weight up any risk you feel might be involved in the action. Risk assessment is based on the probability of an event occurring - such as meeting adverse weather conditions over difficult topography - and on what would be the impact of that event, if it did occur.

Figure 9.4 What is the risk of meeting adverse weather conditions over difficult topography?

Be sure to cultivate a sense of risk awareness, and always fly within the limits of your skill, experience and qualifications.

CHANGING A BAD DECISION.

Do not hesitate to modify an action previously decided upon, if it becomes evident that the initial decision was flawed. A famous Roman, Seneca the Younger, uttered the more famous words *“errare humanum est”: “to err is human”*. But what he actually said is of slightly greater relevance to pilots: *“errare humanum est perseverare diabolicum”*. Those words mean: *“to err is human; to persist is of the Devil”*. A pilot might paraphrase this saying to read: “Make your decision, and take the action you have decided on. But having recognised that you have made a mistake, modify your actions accordingly. Do not persist in your error.” Do you know the expression “pressonitis”? If you do not, ask someone about it.

Do not persist with an erroneous action, once recognised.

THE AIRCRAFT CAPTAIN.

Figure 9.5 Cultivation of leadership and airmanship will ensure that your judgement and decision-making ability are up to the standard required of an aircraft captain.

While acting as Pilot-In-Command, you are the aircraft **captain**. You must, therefore, at all times, remain in command of the situation, of your fellow crew and passengers, and of yourself. The leadership qualities, airmanship and judgement of an aircraft captain are rightly expected to be of a high standard. Cultivation of leadership and airmanship will ensure that your judgement and decision making ability are up to the standard required of an aircraft captain.

“Airmanship” combines a keen awareness of the aircraft and the flying environment, sound decision-making and a highly developed sense of self-discipline with a determination continually to advance piloting skill and mastery of flying theory.

So, whenever you are flying as captain, in order to ensure that your decision-making ability is not degraded by a situation getting beyond your control, you should:

- Plan your flight thoroughly and completely.
- Perform your pre-flight checks thoroughly.
- Not be rushed by others into making a decision.
- Take a pride in the standard of your RT.
- Always be aware of you capabilities and limitations.
- Maintain good situational awareness.
- Constantly monitor and evaluate the progress of the flight.
- Ask for help from ATC early if you find yourself in difficulties.

MECHANICS OF DECISION MAKING.

Sound decision making is the result of logical thought processes. The most common of these processes are shown in the table below.

Steps	Key Points
Diagnose & Define Objective	Identify the most important/urgent problem. Specify the aim or objective. Assess the time available
Collect Information	Collect information from every available source
Risk Assessment	Assess risk
Develop Options	Think through every option to its logical conclusion
Evaluate Options	Weigh and compare options
Decide	Select the best option and decide
Implement Decision	Execute the decision
Consequences	Monitor and evaluate consequences
Review & Feedback	Review whether the situation remains the same and that the decision is still valid. Return to step 1

CONCLUSION.

You should always remember that pilots operate in a dynamic and constantly changing environment. A good decision reached a minute ago will not necessarily be the same good decision in two minutes time; so constantly review the situation in which you find yourself.

Learn all you can and remain flexible.

Finally, you may find it salutary and interesting to consider the type of advice being given to pupil cadets of the Royal Air Force, in 1943, when they were undergoing elementary flying training on such aircraft as the De Havilland Tiger Moth and the Miles Magister. The Air Ministry listed the following advice to aircrew cadets under the title of “Some Golden Rules”. The “rules” are listed in the original words. The flying training being referred to was not aimed at recreational flying, and the times were different. But the words of the “rules” embody an immutable wisdom which echoes down the decades.

Some Golden Rules.

From ‘Air Publication 1979A, Cadets’ Handbook of Elementary Flying Training’. 1st Edition April 1943.

- You are flying for a definitive purpose. Enjoy flying, but don’t treat it as a joke.

- Plan the details of each flight, be it one circuit and landing or a trip to Berlin. To prepare in haste is to repent at leisure.

- Always know what the weather may be expected to do. If the weather looks bad ahead and you don’t feel completely confident of getting through, turn back or force-land. Never trust to the weather improving further on unless you have definite information on the point.

- Give your whole mind to the job in hand. The good pilot, like a good motorist, thinks ahead. If he foresees difficulty, he either arranges to avoid it or prepares to meet it with correct actions.

- Always be alert and watchful. You are rarely alone, on the ground or in the air. Many accidents occur because pilots hesitate to trouble the maintenance staff or ground crews. The pilot is ultimately responsible for his aircraft, and for seeing that other people do their jobs in connection with it.

- Seventy-five per cent of all flying accidents happen when taxing, taking off or landing. These are not difficult things for the experienced pilot to do; the accidents happen when he allows attention and accuracy of performance to lapse.

- Pilots without vigour, initiative and dash make a poor show in battle. But don't bite off more than you can chew. "I'll chance it" are famous last words.

- There are two kinds of pilot: those who panic in emergency, and those who are stimulated to swifter and more efficient action by emergency. The difference is largely one of well-founded confidence.

- Always expect the other fellow to do the unexpected. Then, if he does, you won't be caught napping.

- Stick to proved methods of flying and navigation procedures. They have been worked out from experience and, no matter how clever you are, to neglect them is to ask for trouble.

- Watch your petrol continuously, so that you will always know whether you have enough left to enable you to finish what you propose to do.

- The man who never made a mistake never made anything else. But don't make the same mistake twice. Indeed, there are some mistakes you can't even afford to make once. Remember also that you can learn much from the mistakes of others.

- Watch your own progress and practise those things that you do badly. After a flight, go over it in your mind and extract from it the new lessons that it most certainly has to teach you.

Figure 9.6 Flying a Tiger Moth.

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Representative PPL - type questions to test your theoretical knowledge of Judgement and Decision Making.

1. As captain of an aircraft you will need to show good leadership skills. Which one of the following is <u>not</u> one such skill?

    a. Forward planning
    b. Maintaining good situational awareness
    c. Being aware of one’s limitations and capabilities
    d. Aggressive assertiveness

2. You have planned to take a couple of friends on an air experience flight. On the day, the weather conditions are marginal and there is a strong cross-wind on the runway. As a competent assessor of risk, which of the following decisions should you take?

    a. Get airborne as planned, as it is always wise to stick to your flight plan if you possibly can
    b. Reschedule the flight for another time, discounting the immediate disappointment to your friends
    c. Proceed with the flight and treat it as an opportunity to practise flying in adverse conditions.
    d. Ask your friends if they are prepared to fly in the prevailing conditions.

3. Complete the following statement: Mental Overload usually:

    a. leads to better performance
    b. leads to degraded performance
    c. has no effect on performance
    d. causes changes in the speed and accuracy of performance which vary from individual to individual

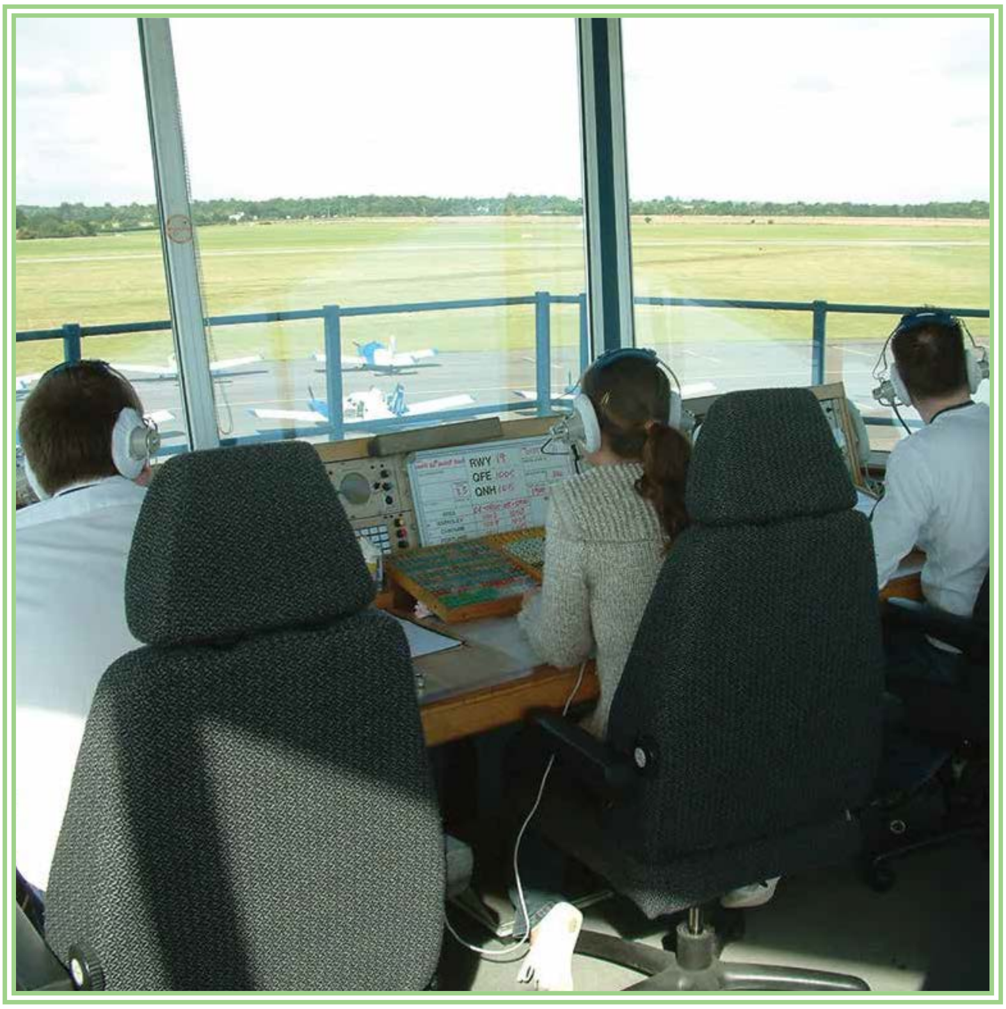
4. Complete the following statement: If, as an experienced pilot, you are flying with someone of much greater experience, and you see him do something you consider to be dangerous, you should:

    a. immediately question his course of action
    b. wait until the action or manoeuvre is completed, and then question him
    c. ignore the situation because he obviously knows what he is doing
    d. do nothing for the moment, but check the wisdom and correctness of his action by discussing it with an instructor after you have landed

Question	**1**	**2**	**3**	**4**
Answer				

The answers to these questions can be found at the end of this book.

CHAPTER 10
VERBAL COMMUNICATION



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INTRODUCTION.

At a busy airport, radiotelephony (RT) communications between Air Traffic Control and pilots are fast and concise. With aircraft landing and taking off every few minutes, it is important that no time is wasted by the pilot or controller hesitating unnecessarily, and even more important that RT transmissions are accurate and easily understood.

Figure 10.1 An Air Traffic Control Tower.

But use of the RT is only one example of when good verbal communication is necessary. When piloting an aircraft, whether with passengers, another pilot or an instructor, good verbal communication between aircraft occupants will help the flight proceed smoothly, and contribute to Flight Safety.

In this chapter, we will look at several communications scenarios that may arise in the cockpit, learn why good pre-flight briefings are necessary, and look briefly at factors which may be injurious to good communications.

COMMUNICATION IN THE COCKPIT.

You will find yourself in numerous situations where good cockpit communication is essential to the safe and expedient conduct of a flight. Here are three common examples:

If two similarly qualified pilots fly together, a Pilot-In-Command must be designated.

Figure 10.2 Good communication between crew members is essential.

Example 1: Pilot to Pilot - Pre-take off Brief.

Before any flight where two similarly qualified pilots are at the controls, one of the pilots must be declared the Pilot-In-Command. It should also be established, between the two pilots, what action should be taken by which pilot, if an emergency situation, such as an engine failure on take-off, should occur. Events happen very rapidly in an emergency and there will be no time to decide who does what when things start to go wrong.

So, before take-off, the nominated Pilot-In-Command might brief his companion as follows:

"In the event of an emergency, I will maintain control. If we have an engine failure before reaching take-off speed, I will bring the aircraft to a halt on the runway. If we have an engine failure below 200 feet, I will land back on the runway, if possible, otherwise I will land straight ahead outside the airfield perimeter." And so on.

If such a briefing were missed, neither pilot would be sure about who would have control of the aircraft if an emergency occurred at this critical point in the flight.

Example 2: Pilot to Passenger - Safety Brief.

Briefings to passengers before take-off are essential. You will not have time to brief passengers during an emergency in the air. If an emergency occurs, the pilot's whole attention is required to deal with the emergency situation. If a private pilot were carrying a passenger beside him, he might brief the passenger as follows, before calling "Ready for departure":

"In the event of an emergency landing, I will ask you to unlatch the door and tighten your seat belt at a suitable time before touchdown. After landing, you should exit the aircraft and move away from the aircraft towards the tailplane."

The briefing and care of passengers is dealt with fully in Chapter 7.

Example 3: Student Pilot and Instructor - Handing Over Control.

At any point during a training sortie, the instructor may take control of the aircraft in order to demonstrate or teach a manoeuvre or technique, and then hand control back to the student so that he can practise for himself. Whenever control of the aircraft changes hands, it must be clear to both student and instructor which of the two has control. Consequently, a formal hand-over/take-over procedure exists which should always be followed. Your instructor will brief you on this.

PRE-FLIGHT BRIEFINGS.

A thorough pre-flight briefing will make the sortie much more meaningful for a student or passenger.

Information essential to a training sortie or flight with passengers must be given to students and passengers in the form of a formal pre-flight briefing. *(See Figure 10.3*).

Figure 10.3 Good pre-flight briefings help a student to understand what is required of him.

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Good pre-flight briefings will help a student tremendously in understanding what his instructor requires him to achieve in the air. On the other hand, bad briefings can cause confusion and actually make airborne communication worse.

A good briefing should fulfil several criteria:

- It should be short, so that the person being briefed is not overloaded with information.
- It should be relevant to the sortie to be flown, and not contain superfluous information.
- It should follow recommended good-practice, as taught on flying instructor courses.
- It should conclude with a question and answer session, to check understanding.

BARRIERS TO COMMUNICATION.

Good verbal communications are essential to the safe and efficient conduct of flights. All aircraft occupants, whether passenger or student pilot, must be given information, advice and/or instruction by the Pilot-In-Command, in clear, concise and unambiguous terms. Communications with ground radio stations must also be clear, concise and unambiguous, as well as being procedurally correct.

Although instruction in verbal communications relevant to pilots is usually limited to instruction in radiotelephony, all pilots must be aware of the importance to Flight Safety of all categories of communication.

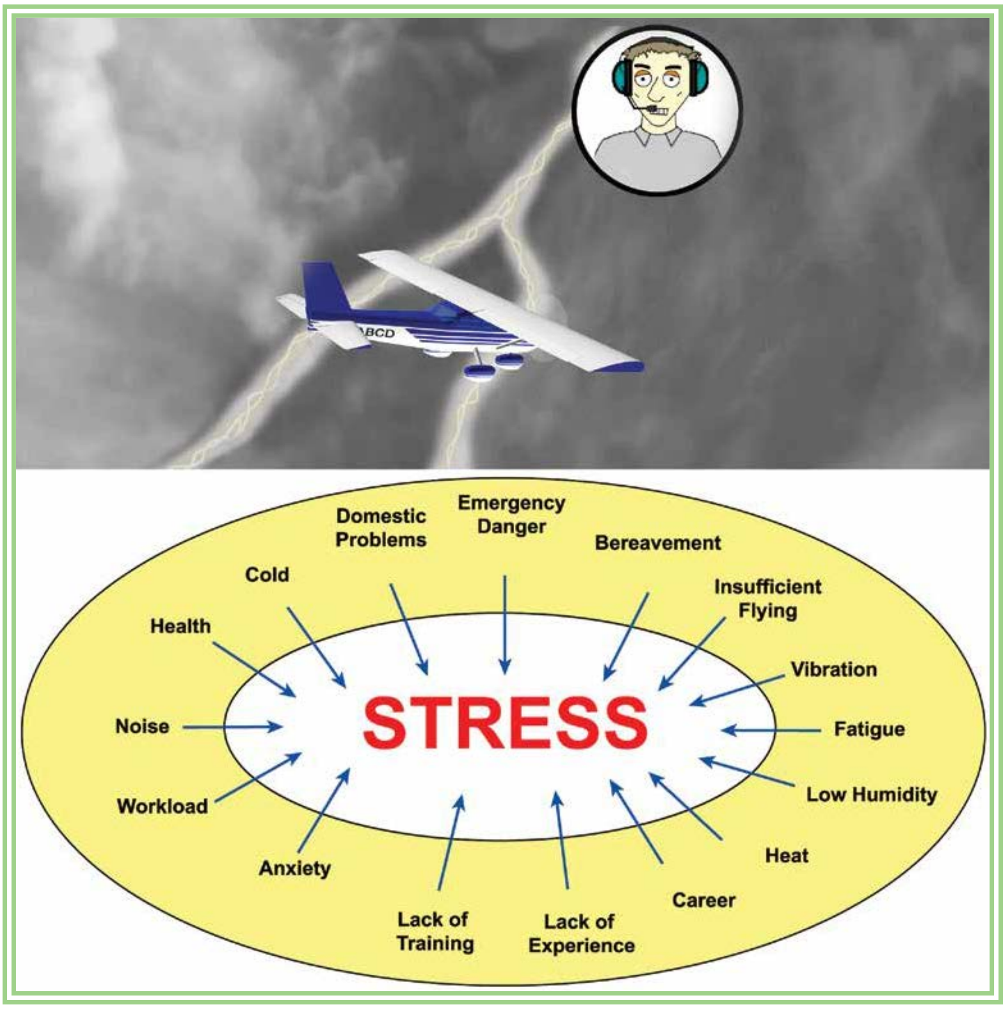
If you become a flying instructor, you will quickly learn that the ability to communicate effectively with the student pilot is especially important. Developing this ability to communicate verbally through standard instructional phraseology, often called patter, is an important element of instructor training.

One essential factor in the development of good verbal communication skills is a realisation, on the part of the pilot, of how certain attitudes can build up barriers to communication.

Attitudes and behaviour patterns that have been shown to be especially injurious to good verbal communication in the air are:

- Excessively authoritarian behaviour.
- Impulsiveness.
- Aggressiveness.
- Arrogance.
- Resignation.
- Irresponsibility.

CHAPTER 11
STRESS



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INTRODUCTION.

Stress is commonly defined as the body's response to the demands placed upon it. Thus, stress is the reaction to events and circumstances which are stressful, not the events and circumstances themselves. Events and circumstances which cause stress are known as stress factors or stressors.

Figure 11.1 Physical Stress Factors and Stressors.

Stress can be physical, where the body is exposed to excess heat, cold or force *(See Figure 11.1)*. Stress can also be mental or emotional, when circumstances are such that our reasoning and decision making faculties are affected by external events.

Mental and emotional stresses are much harder to quantify than physical stresses, but stress is recognised as being a natural condition of life and is a normal reaction to demanding situations. We also know that while stress is a necessary condition for coping with life's demands, too much stress is harmful. Thus, while a certain level of stress is of fundamental importance in keeping us aware and vigilant, too much stress will degrade the performance of both body and mind, and can eventually lead to ineffective decision making, mental breakdown and long-term serious illness.

Stress is recognised as being a natural condition of life, and a certain level of stress is necessary to keep us aware and vigilant.

Figure 11.2 Low stimulation can lead to boredom or even drowsiness.

Arousal.

The different stress levels generated within individual persons by a particular stressor will differ from one individual to another. Thus some people are more tolerant of stress than others. The response of a person to the event or circumstances to which he is exposed is known as arousal.

One way of defining arousal is to say that it is the measure of the human being's readiness, fitness and ability to respond effectively to a given stress factor. The level of arousal of different human beings will depend on their inborn and acquired characteristics as well as their state of health.

Inborn characteristics may include an individual's "personality" or "character". Among acquired characteristics, we may identify an individual's level of training and experience in a given field of activity.

In an active, outward-going, highly trained person, too little stimulation or arousal will lead to the onset of boredom and even drowsiness. Such a person might need significant challenges in his specialist field in order to function optimally. *(See Figure 11.2).*

Figure 11.3 High Arousal in Challenging Meteorological Conditions.

Conversely, an introspective, under-confident person, if highly aroused, might be unable to function at all, even in circumstances that he is competent to deal with. If such a person is under-trained, his level of arousal and the stress that he feels might cause him serious problems.

Flying in challenging meteorological conditions *(See Figure 11.3)* may be even a welcome occurrence for a skilled and experienced pilot and stimulate him to demonstrate extraordinary skill, whereas such conditions may cause unbearable stress in an under-confident, low-hours pilot, and lead to a degradation in basic flying skills.

In *Figure 11.4,* the relationship between levels of arousal and performance is shown.

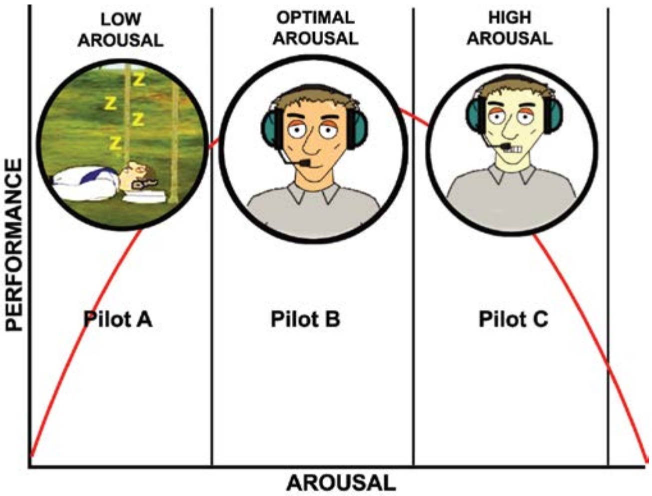

Figure 11.4 Arousal States.

Evidently, pilot B is in a state of optimal arousal where a human being operates at his most efficient.

Pilot C may be considered as being in a state of high arousal *(See Figure 11.3)*. Here, a person's performance starts to deteriorate. He will begin to commit errors and overlook items of information. His attention span will narrow and he will tend to focus on a limited source of data. If very high arousal levels are reached, the pilot may experience **overload** and reach the limit of his information processing capacity and ability to cope with the task in hand.

It is easy to see how such a high state of arousal might result in a pilot-induced accident.

At the other extreme of the graph, that is at low arousal, such as when we are relaxing on a sun-soaked airfield following a satisfying flight, (Pilot A), our information processing capacity is again low, and our performance potential is poor.

There is no doubt that training and experience help to ward off stress and high levels of arousal. And successful completion of a demanding task will reduce the amount of stress experienced when a similar task is undertaken in the future.

Stress Levels.

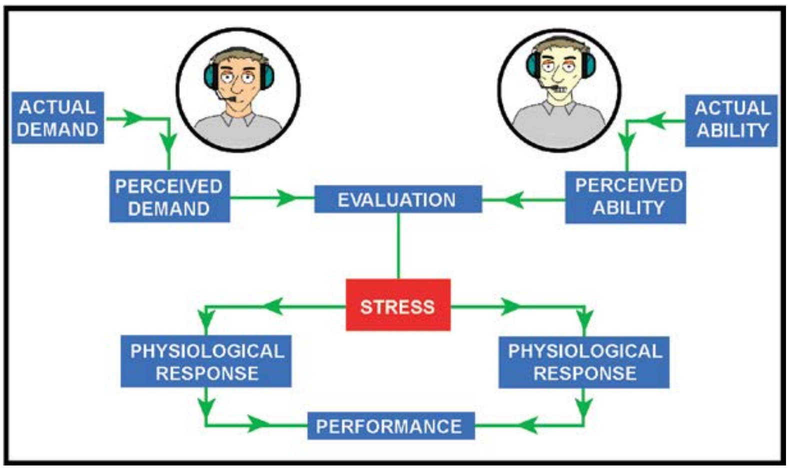

Figure 11.5.

Successful completion of a demanding task will reduce the amount of stress experienced during a subsequent task of the same nature.

The level of stress felt by any individual is a function of the demands which he perceives to be placed upon him and of the ability he perceives he has to cope with the demands. It is, then, the person's evaluation of the demands imposed upon him rather than the demands, themselves, which will determine the level of stress he feels. Similarly, it is a person's perception of his own ability to cope with a given demand, rather than his actual measured ability, which determines the amount of stress he feels.

The body's feedback mechanism is of great importance in determining the amount of stress experienced by an individual on subsequent performances of the task. Successful completion of a given task will cause a person to perceive that the demand placed on him fell within his ability to accomplish the task. His original evaluation of the task will, thus, be changed and the level of stress he feels will be reduced on undertaking a similar, subsequent task. The opposite, of course, is also true. Failure to complete a task will induce high stress levels in an individual if the task has to be repeated.

Stress Factors and Stressors.

There are many recognised causes of stress, (i.e. stress factors or stressors), some of the most common of which are shown on *Figure 11.6 (see overleaf)*. An important fact to remember about stress factors is that they are cumulative. If a pilot happens to be subject to a minor stress factor, and then another stressor kicks in, his stress level will increase out of proportion to the stress he would feel if the second stress factor were the only one affecting him. Thus, if a pilot, having had an argument with a colleague on the ground, then flies and encounters another small problem when airborne, his stress level will rise to a higher level than if the pre-flight argument had not taken place.

Stress factors are cumulative. They reinforce one another and can subject an individual to severe stress.

Figure 11.6 Stress factors.

You must be able to recognise stress in yourself and be prepared to do something about it.

Common Stress Factors.

The most common stress factors likely to affect a pilot in the cockpit are health, heat or cold, noise, vibration, workload, anxiety, lack of training, lack of experience, fatigue and emergency or danger *(see Figure 11.7 below)*.

Figure 11.7 The most common stress factors.

Health, emergencies and fatigue are dealt with elsewhere in this course. As far as cockpit workload is concerned, thorough flight planning is the key to reducing this particular stress factor, as is the efficient organisation of all charts and documents that are to be referred to in–flight.

Make sure, then, that your cockpit housekeeping is of a high order and that all documents, charts and associated equipment are appropriately stored and accessible, in accordance with the principles of flight safety.

High quality headsets will reduce cockpit noise levels.

Temperature can often be regulated using the cabin heating or ventilation system. If this is not an option, make sure that you are wearing appropriate clothing for the altitude and season.

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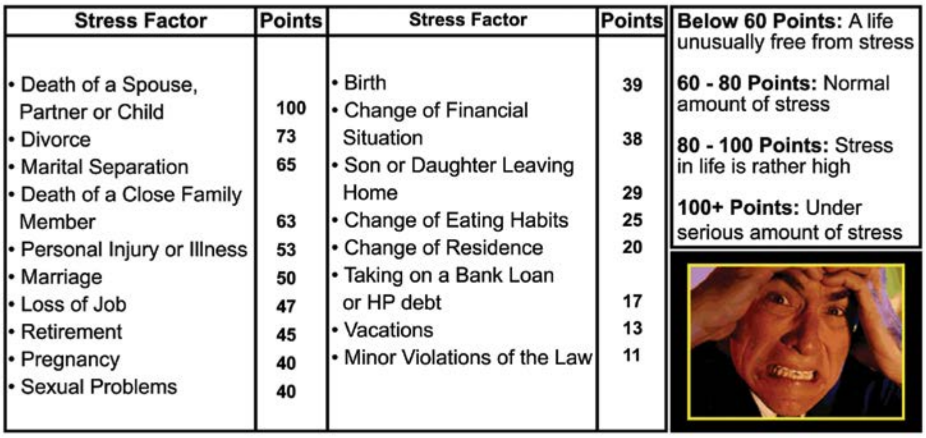
Factors such as lack of training, lack of experience and anxiety are inter-related. Stress caused by these factors can really only be avoided, not relieved immediately once a problem has arisen. The best way of avoiding such stress is to know your limits and fly well inside them. Do not attempt to fly sorties or routes which impose demands on you for which you have not been trained. If you are trained but lack experience, fly with a more experienced colleague until you have gained confidence.

If you are aware that you are under stress because of any of the stress factors which appear in *Figure 11.7*, consider whether it would not be wiser for you to stay on the ground rather than to fly.

Stress in every day life can affect piloting performance as indeed piloting performance can cause stress in the pilot's work and home life. Pilots suffering from stress related to domestic and/or work problems should be aware that this can affect their concentration and performance when at the controls of an aircraft. There is some evidence for a relationship between life stresses and flying accidents.

Measuring Stress Levels.

Attempts have been made to assess stress levels in general. Although reaction to various stress factors varies from individual to individual, the table at *Figure 11.8* gives a suggested weighting for various stress factors that can affect a person's life.



Stress Factor	Points	Stress Factor	Points
• Death of a Spouse, Partner or Child	100	• Birth	39
• Divorce	73	• Change of Financial Situation	38
• Marital Separation	65	• Son or Daughter Leaving Home	29
• Death of a Close Family Member	63	• Change of Eating Habits	25
• Personal Injury or Illness	53	• Change of Residence	20
• Marriage	50	• Taking on a Bank Loan or HP debt	17
• Loss of Job	47	• Vacations	13
• Retirement	45	• Minor Violations of the Law	11
• Pregnancy	40		
• Sexual Problems	40		

Below 60 Points: A life unusually free from stress

60 - 80 Points: Normal amount of stress

80 - 100 Points: Stress in life is rather high

100+ Points: Under serious amount of stress

Figure 11.8 Points table for Stress Factors.

As stress is cumulative, the points score for all of the stressors in *Figure 11.8* should be totalled to give an indication of the stress acting on any given person at any given time. As a pilot, you can learn to avoid stress in the cockpit, and to reduce or manage the effect of the more common stress factors associated with flight and aircraft operations.

Avoid Stress in the Air.

Some methods of avoiding coming under stress when you fly are:

- Adopt a professional approach to all your flying activities. There will then be little possibility of your being surprised by situations or developments in the air.

- Whatever your level of experience as a private pilot, ensure that you fly with an instructor at least twice a year.

In order to cope with stress successfully, you must recognise the stress factors that are affecting you.

- Ask the instructor to comment on your general and procedural flying and get him to give you practice emergencies to deal with such as getting lost, engine failure after take-off, or fire in the air.

- You should learn from the past, including from the experience of others. If you have committed a piloting error, therefore, discuss it with an instructor or with your fellow pilots *(See Figure 11.9)*. Write down what you and others perceive to have been the causes of your error. This way, you will be less likely to re-offend.

Figure 11.9 Discuss piloting issues with an instructor.

- Be thorough in your pre-flight briefing and preparation. This will enable you to anticipate in-flight events and will contribute greatly to reducing workload in the cockpit.

Coping with and Reducing Stress.

In order to cope with stress successfully, it is fundamental that you be aware that you are under the influence of stress factors. Only then can you identify the stress factors, and either remove yourself from them or modify them in order to reduce your stress level. So, in order to help reduce the impacts of flying-related stress-factors, and to avoid or mitigate stress in the cockpit, consider the following advice:

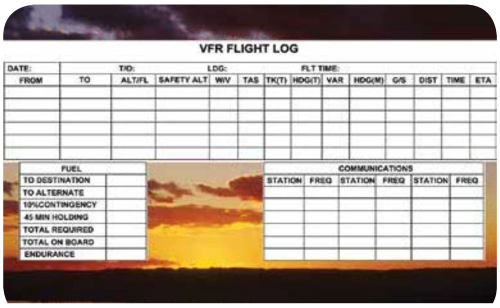
Do not rush actions or decisions.

Figure 11.10.

- Do not let people or circumstances rush you into acting before you are ready. Air Traffic Control and ground-based duty personnel are understandably keen to get you airborne, but, while remaining mindful of the necessity to work expeditiously, do not be pressed by outside influences into committing an error of airmanship. If necessary, ask ATC to "standby."

Figure 11.11 Do not allow yourself to be rushed or distracted.

- Do not be distracted from your pre-flight checks. If you are interrupted during your checks, go back several items before continuing to work through the check list.



VFR FLIGHT LOG

DATE:	T/O:			LDG:				FLT TIME:					
FROM	TO	ALT/FL	SAFETY ALT	W/V	TAS	TK(T)	HDG(T)	VAR	HDG(M)	G/S	DIST	TIME	ETA

FUEL	
TO DESTINATION	
TO ALTERNATE	
10%CONTINGENCY	
45 MIN HOLDING	
TOTAL REQUIRED	
TOTAL ON BOARD	
ENDURANCE	

COMMUNICATIONS					
STATION	FREQ	STATION	FREQ	STATION	FREQ

Figure 11.12.

- When airborne, stick to your pre-flight plan unless a change is absolutely necessary.

Figure 11.13.

- Ask ATC to "say again" if you do not understand an RT transmission. However, make sure that you learn your RT well.

Figure 11.14.

- If faced with bad weather or with flying conditions that you are not trained, qualified or equipped to deal with, make an early decision to turn back or divert.

Finally, if you are planning to fly with another qualified pilot, agree, before walking to the aircraft, who will be the designated Pilot-In-Command and which principal in-flight tasks each of you will perform. This will prevent either one of you becoming overloaded, and will avoid confusion in the air about who is responsible for the various piloting tasks, and for the aircraft in general.

Figure 11.15.

Summary.

Accept that stress is an unavoidable by-product of living and can be especially complex in the modern technological age. Your ability to control and/or cope with potentially stressful situations will have a marked effect on your ability to function effectively. Finally, do not take your troubles into the cockpit with you. If you cannot leave them behind, do not fly as a pilot.

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Representative PPL - type questions to test your theoretical knowledge of Stress.

1. A moderate level of arousal will:

   a. Lead to a breakdown in health over a period of time
   b. Produce interest in external events and performing tasks
   c. Lead to slow processing of sensory information
   d. Lead to deterioration of performance due to narrowing of attention

2. The life event that is considered to produce the most stress is:

   a. Minor violations of the law
   b. Marital separation
   c. Personal injury or illness
   d. Death of a partner or spouse

3. Having successfully overcome a stressful situation once, how will the person react if placed in the same or similar situation a second time?

   a. There will be little difference
   b. Stress will increase because he will be afraid of what he knows lies ahead
   c. Stress will reduce because, having already successfully overcome the stressful situation, he will be confident he can do so again
   d. Experience can not affect reaction to stress

4. An important factor to remember with regard to stress factors is:

   a. They decay with time
   b. They are cumulative
   c. They are objective in nature
   d. They affect all pilots equally

5. The relationship between arousal and performance means:

   a. Performance is degraded by under-arousal and improved by over-arousal
   b. Performance is improved by both under and over-arousal
   c. Performance is degraded by both under and over-arousal
   d. Performance is improved by under arousal and degraded by over-arousal

6. Which of the following statements is false?

   a. All people react in the same way to the same stressful situation
   b. Stress is a natural condition of life
   c. Stress is cumulative
   d. The right training can make a stressful task less stressful

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7. Complete the following statement. The level of stress felt by an individual is dependent on:

    a. actual ability
    b. perceived demand
    c. a combination of perceived demand and actual ability
    d. none of the above

8. You are positioned short of the holding point and are in the middle of your pre take-off checks when you receive clearance to take-off from ATC. The wisest course of action is:

    a. Ask ATC to “standby” and complete your checks properly, recommencing your checks by going back over the last one or two previously completed items on your check list.
    b. Rapidly run through your remaining checks, acknowledge ATC’s clearance and take-off.
    c. Skip the last few items on your checklist and take-off as cleared.
    d. Ignore ATC, and finish your checks before replying.

9. What are Stress Factors or Stressors?

    a. Pulse-rate inducers
    b. Circumstances or events which provoke any kind of reaction to the demands placed upon the human organism
    c. Events and circumstances which cause stress
    d. Measures of stress exhibited by a person

Question	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Answer									

The answers to these questions can be found at the end of this book.

CHAPTER 12
THE COCKPIT

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INTRODUCTION.

Cockpit Design and Layout.

In the conception and production of a new aircraft type or model, cockpit design has a profound influence on how effectively and efficiently the pilot will operate in the air. Cockpit space and comfort, the design and layout of instruments and controls, and the extent of the pilot's visual field, in terms of his being able to take in the instrument and control layout at the same time as having a satisfactory view of the outside world, are of particular importance.

Over the past 90 years or so, the design and instrument layout of the light aircraft cockpit has evolved steadily, though basic features have remained fairly constant. Until very recently, the main improvements in light aircraft cockpit design have centred around the ergonomics of the cockpit: the comfort of the pilot, the extent of the visual field offered by improved canopy design, and, in the last few years, advances in instrumentation, both in capability and clarity of display.

Figure 12.1 Over the years, cockpit design has evolved steadily while retaining many constant features.

The most revolutionary change in cockpit design in recent years has been the advent of the glass cockpit, where traditional, analogue instrument displays, with their needles and cross-bars, have been replaced by computer-controlled electronic displays that can display various types of flight information, as selected by the pilot. The capability of the instruments themselves has advanced rapidly, too. Most professional pilots now have the benefit of Electronic Flight Instrument Systems, which display navigation and attitude information, Flight Management Systems, which help pilots with their flight planning, Traffic Collision Avoidance Systems, Ground Proximity Warning Systems, and Global Positioning Systems.

Figure 12.2 The most revolutionary change in recent years has been the advent of the glass cockpit.

By the 1990s, glass cockpits were becoming more and more common in airliners, and, nowadays, glass cockpits are even an option in light training aircraft.

It is not, however, the purpose of this chapter to look at these latest developments in the capability and display features of aircraft instruments, but rather to examine how more general cockpit design considerations attempt to take into account the comfort of the pilot and the need for him to operate safely and efficiently.

Anthropometry.

One of the most important factors in determining the size of an aircraft cockpit is the size of the occupants that the aircraft is designed to carry.

Anthropometry is the name given to the study of the measurement of human beings. From anthropometrical data an enormous amount of information is available to the aircraft designer about the range of sizes of potential pilots, crew and passengers.

Anthropometrical information may be placed into two main groups.

- Static measurements, such as height, ankle-to-knee distance, shoulder width etc.
- Dynamic measurements, such as how far a human being can reach or stretch his legs.

Figure 12.3 Little pilot, big pilot.

Having determined the range of different measurements that exist within any population of human beings, the aircraft designer must decide which spread of measurements he will take into consideration in order to determine the size of the cockpit. It is not feasible to allow for all the different sizes of adults. It is not practical, for instance, to design a single cockpit which can be operated by both the very short and the very tall. Consequently, aircraft designers will normally cater for the middle 90% of human beings, in terms of size. Those in the lowest 5% and those in the highest 5% of size range are not considered.

In the United Kingdom, the 5th percentile of height for adult males is 5 feet 4ins (1.625m) (i.e. 5% of adult males are shorter than this) and the 95th percentile is 6 feet 1in (1.855m) (i.e. 5% of adult males are taller than this).

EYE DATUM.

Ask your instructor to help you determine the ideal seating position so that you can make the most of your flying instruction.

One of the basic design criteria for cockpits is that the pilot should be able to view all of the important instrument displays within the aircraft while maintaining an adequate forward view through the canopy without the need to make more than the minimum number of head movements. It follows, therefore, that the cockpit space must be designed around a defined position of the pilot's eye-level.

This position can be called variously the eye datum, the design eye position, or the reference eye point.

Figure 12.4 Adequate forward view.

The eye datum is sometimes indicated in the cockpit by the provision of an indicator on the central windscreen pillar, which only appears to be aligned when the pilot's eye is at the designed point.

As the external view is of great importance in piloting the aircraft, the pilot must, without strain, be able to look over the top of the instrument panel and see sufficient of the ground ahead to enable him to fly the aircraft by external references, both in the cruise and on approach to land.

If the pilot is sitting too high in the cockpit, he will have a good downward view, but his view of the flight instruments may be less than optimal.

If, on the other hand, the pilot is sitting too low, he may not be able to see the horizon adequately in the cruise, or have an adequate view of the undershoot on the approach to land.

Once the eye datum has been established by the designer, and the anthropometric range of pilots has been determined, the size of the cockpit work space and the amount of adjustment to seat, rudder pedals, etc, can be determined.

From your point of view as a pilot, ensure that you ascertain the correct seat adjustment for yourself, from your very first flying lesson.

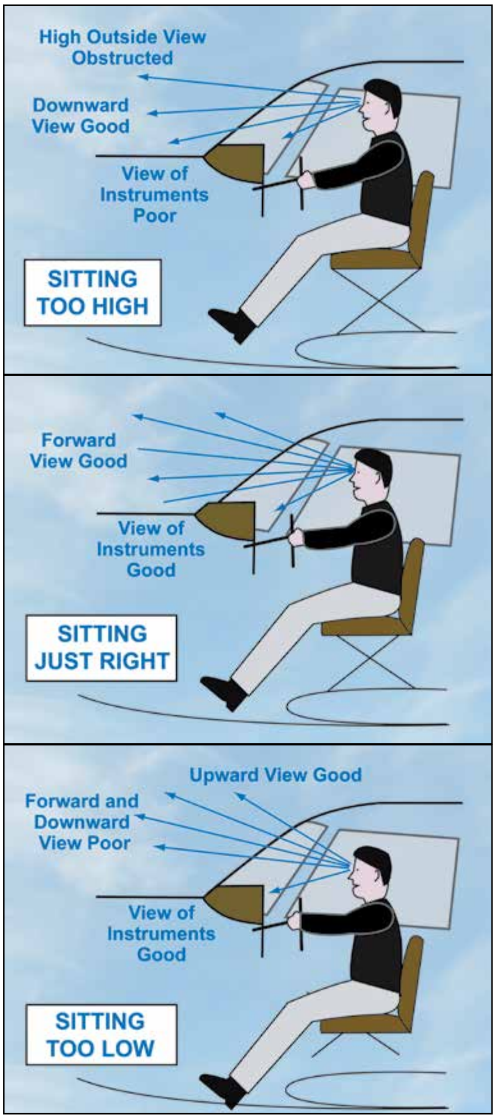

Figure 12.5a-c Eye datum positions.

The pilot must have a clear view of the instruments and a good forward view through the canopy, so that he can see the horizon, and the undershoot on approach.

A Satisfactory View.

From your seating position, with all harnesses tight and locked, you must have a clear view of the instruments and over the nose of the aircraft so that you can correctly judge cruise and approach attitudes.

You must also be able to reach all the controls and manipulate them over their full range of movement. Ask your instructor to help you determine the ideal seat adjustments for you. Effort spent on this detail will help you gain maximum benefit from your flying, whether you are a student or qualified pilot.

Figure 12.6 depicts the type of view you should expect to have in cruising flight.

Figure 12.6 A satisfactory view of the horizon in cruising flight.

The forward field of vision you should expect to have on approach is depicted in *Figure 12.7*

Figure 12.7 A satisfactory view of the approach.

DESIGN OF COCKPIT SEATS.

You will be working hard during your flying lessons and, once qualified, may hope to do some challenging cross-country flying. Therefore, it is of the utmost importance that your seating position should be comfortable and adjustable to your height and build.

Cockpit seats should ideally have a lumbar support to maintain the natural spine shape and, thereby, reduce back pain and fatigue. Additionally the seat should, if possible, be isolated from any vibration of the airframe. When adjusting their seats, pilots should attempt to establish a comfortable position that facilitates full control movement, together with a balance between a full instrument scan and outside visibility. This personalised position should be used for all subsequent flights.

Figure 12.8 Five-point harness with negative g strap.

Harness-fit and adjustment is important, too. The pilot must be able to function efficiently with his harness secure and adjusted.

A 5-point harness with a negative g strap. is shown in *Figure 12.8.*

INSTRUMENT DISPLAYS.

Display and Presentation Requirements.

When deciding on the best way to display flight information, the basic choice for an aircraft designer is between a digital or analogue display.

Experiments suggest that for the display of purely quantitative information, the amount of fuel in a tank for example, digital displays might be more effective *(See Figure 12.9).*

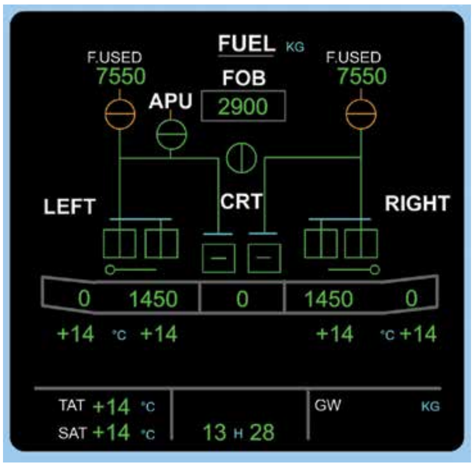

Figure 12.9 Digital fuel gauge.

Figure 12.10 Analogue ADF/VOR display.

Figure 12.11 Digital displays can be programmed to simulate analogue instruments.

For displaying qualitative information, and for information which needs to be compared and contrasted, **a**nalogue displays provide more easily assessed information. When interpreting navigational information from VOR and ADF equipment, for instance, analogue displays give highly effective situational awareness *(See Figure 12.10).*

Even when digital displays are used in modern glass cockpits, the digital information is often presented as a simulated analogue display, as depicted in *Figure 12.11.*

Conventional Analogue Standard 'T' Display.

Figure 12.12 The standard 'T' instrument panel.

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The basic instrument panel of a conventional instrument display will invariably be of a standard 'T' layout with the most important instrument, the artificial horizon or attitude indicator in the upper central position. The other basic flight instruments, the airspeed indicator, the altimeter and the direction indicator are grouped around the artificial horizon to form a T-shape.

It is almost certain that the basic flying training aircraft in which you learn to fly will be equipped with analogue instruments.

Analogue Displays - The Compass, Direction Indicator and Altimeter.

Many pilots find that an analogue direct-reading compass and direction indicator give a better picture of the aircraft orientation than would a digital readout. *(See Figure 12.13).* A digital readout for heading makes it more difficult to determine such information as the shortest way to turn onto a new heading.

Figure 12.13 Analogue display of heading information is more intuitive than a digital display.

Combination of Analogue and Digital Display.

It is practicable in some instances to combine both digital information and analogue information in a single instrument, as seen in the altimeter at *Figure 12.14* where the thousands and hundreds of feet are displayed digitally. The hundreds of feet are also shown by a single pointer. While the digital display gives the pilot a clear and unambiguous indication of his altitude or height, the use of a single moving pointer against a fixed scale allows the pilot to judge when the end of the scale is being approached, i.e. when he is approaching the ground.

Figure 12.14 Combined analogue and digital information.

The single analogue needle is also excellent for showing <u>small</u> changes of altitude such as when levelling off or departing inadvertently from the selected altitude.

The 3-Pointer Altimeter.

The 3-pointer altimeter, depicted in *Figure 12.15*, has been in use for many years and is still the most commonly-used principal altimeter fitted to light aircraft. Pilots must be aware, though, that the 3-pointer altimeter can easily be misread. The 3-pointer altimeter shown here is indicating 2 720 feet, exactly the same altitude as indicated by the altimeter in *Figure 12.14.* Notice, however that the the 3-pointer altimeter is not so easy to interpret.

Figure 12.15 3-pointer altimeter.

AIRCRAFT CONTROLS.

The instruments pass information from the aircraft and its environs to the pilot. The aircraft's controls, on the other hand, pass instructions from the pilot to the aircraft.

There are certain basic considerations which govern the way that aircraft controls should be designed and located in the cockpit. Most importantly, controls should be standardised, in as far as is possible and sensible, from the point of their design, location, and the sense in which they are used, between all aircraft types and models. Controls should also be located so that they are within easy reach of the pilot. Furthermore, controls that are used frequently, or for protracted periods, should be located so that they do not require the pilot to adopt an awkward or tiring posture.

Controls that are normally used in a given order should be laid out so that the sequence of use is represented in that layout. As well as being ergonomically convenient, the order of the layout, itself, will act as a prompt for the pilot to operate the controls in the correct sequence.

Figure 12.16 Controls which are used frequently should not require the pilot to adopt an awkward or tiring posture.

Figure 12.17 *Important controls must be easy to reach.*

Levers, switches and knobs which control different functions must look and feel different from one another.

Important controls must be located in easily reached and unobstructed positions. Levers, switches and knobs which control different systems or functions should look and feel different from one another *(See Figure 12.18)*. This is an important and fundamental consideration in order to reduce the risk of the pilot mistaking one control for another and making an incorrect, and potentially dangerous, control input.

Those controls that the pilot may need to use simultaneously, or consecutively, such as the throttle and mixture controls, should be located adjacent to each other *(See Figure 12.19).*

Figure 12.18 Levers, switches and knobs which control different functions must look and feel different.

Figure 12.19 Throttle and mixture controls.

CHECKLISTS.

Introduction.

A well-designed checklist is fundamental to the safe operation of an aircraft. Pilots must be able to access accurate information in manuals and checklists as rapidly as possible, with the minimum possibility of their making an error of interpretation. Of course, pilots themselves have a responsibility to be sufficiently familiar with their documentation so that they know where to find relevant information in the shortest possible time.

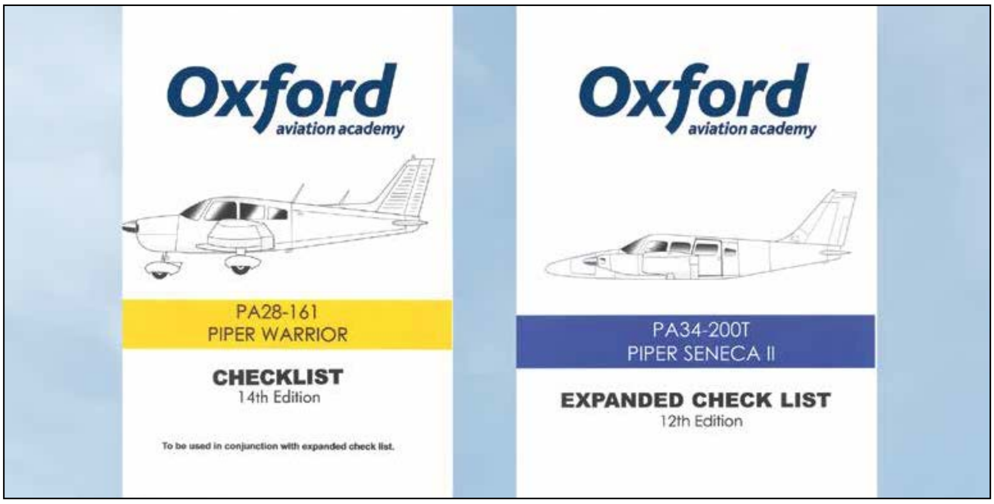
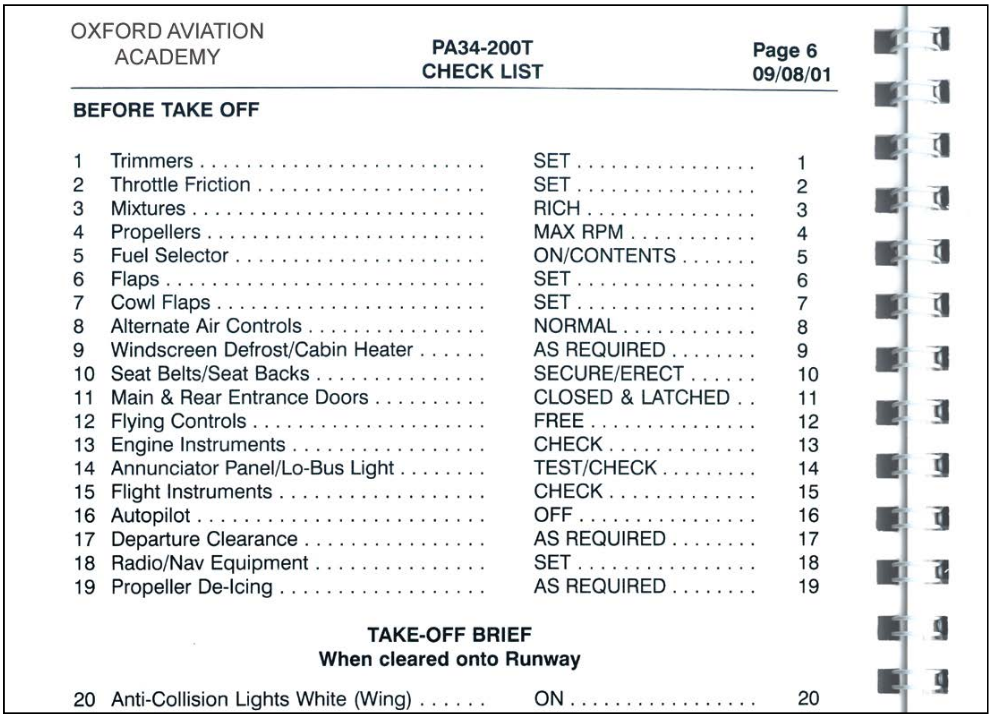


Figure 12.20 Checklists are of fundamental importance to the safe operation of an aircraft.

Checklist Design Requirements.

A well designed checklist should be:

- ***Unambiguous.***



OXFORD AVIATION
ACADEMY

PA34-200T
CHECK LIST

Page 6
09/08/01

BEFORE TAKE OFF

1	Trimmers	SET	1
2	Throttle Friction	SET	2
3	Mixtures	RICH	3
4	Propellers	MAX RPM	4
5	Fuel Selector	ON/CONTENTS	5
6	Flaps	SET	6
7	Cowl Flaps	SET	7
8	Alternate Air Controls	NORMAL	8
9	Windscreen Defrost/Cabin Heater	AS REQUIRED	9
10	Seat Belts/Seat Backs	SECURE/ERECT	10
11	Main & Rear Entrance Doors	CLOSED & LATCHED	11
12	Flying Controls	FREE	12
13	Engine Instruments	CHECK	13
14	Annunciator Panel/Lo-Bus Light	TEST/CHECK	14
15	Flight Instruments	CHECK	15
16	Autopilot	OFF	16
17	Departure Clearance	AS REQUIRED	17
18	Radio/Nav Equipment	SET	18
19	Propeller De-Icing	AS REQUIRED	19

TAKE-OFF BRIEF
When cleared onto Runway

20	Anti-Collision Lights White (Wing)	ON	20

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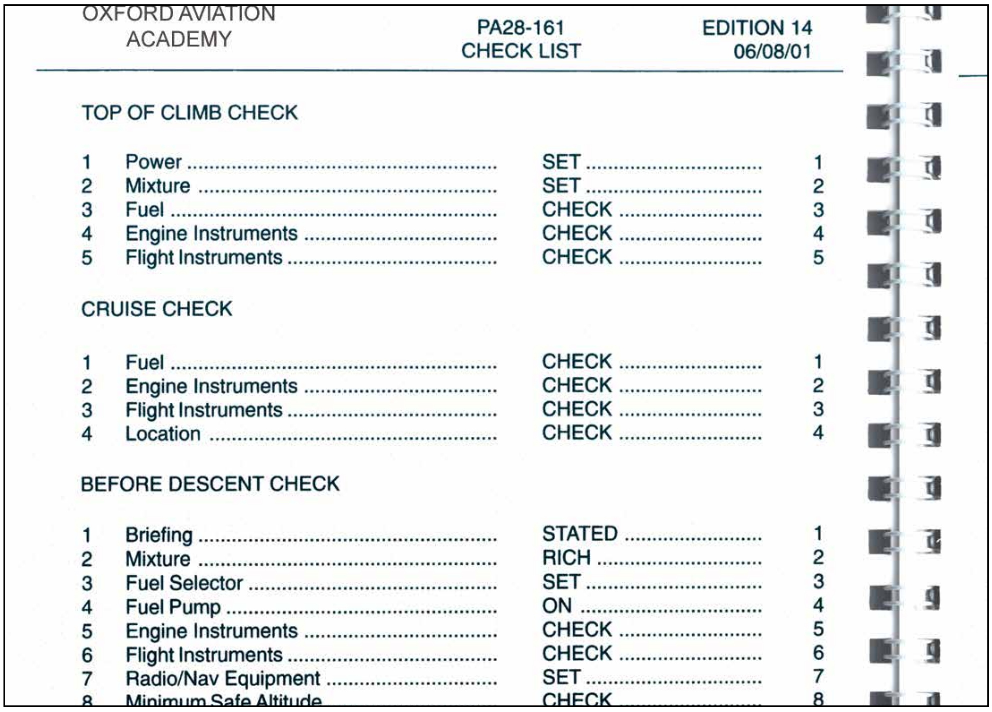
- ***Presented in easily understood language.***



OXFORD AVIATION
ACADEMY

PA28-161
CHECK LIST

EDITION 14
06/08/01

TOP OF CLIMB CHECK

1	Power	SET	1
2	Mixture	SET	2
3	Fuel	CHECK	3
4	Engine Instruments	CHECK	4
5	Flight Instruments	CHECK	5

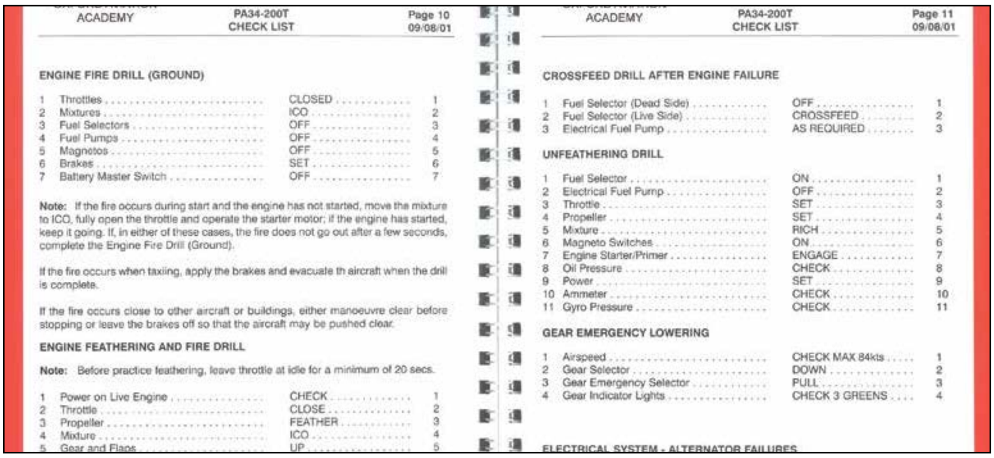
CRUISE CHECK

1	Fuel	CHECK	1
2	Engine Instruments	CHECK	2
3	Flight Instruments	CHECK	3
4	Location	CHECK	4

BEFORE DESCENT CHECK

1	Briefing	STATED	1
2	Mixture	RICH	2
3	Fuel Selector	SET	3
4	Fuel Pump	ON	4
5	Engine Instruments	CHECK	5
6	Flight Instruments	CHECK	6
7	Radio/Nav Equipment	SET	7
8	Minimum Safe Altitude	CHECK	8

- ***Colour coded by topic area.***



ACADEMY

PA34-200T
CHECK LIST

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09/08/01

ENGINE FIRE DRILL (GROUND)

1	Throttles	CLOSED	1
2	Mixtures	ICO	2
3	Fuel Selectors	OFF	3
4	Fuel Pumps	OFF	4
5	Magnetos	OFF	5
6	Brakes	SET	6
7	Battery Master Switch	OFF	7

Note: If the fire occurs during start and the engine has not started, move the mixture to ICO, fully open the throttle and operate the starter motor; if the engine has started, keep it going. If, in either of these cases, the fire does not go out after a few seconds, complete the Engine Fire Drill (Ground).

If the fire occurs when taxiing, apply the brakes and evacuate th aircraft when the drill is complete.

If the fire occurs close to other aircraft or buildings, either manoeuvre clear before stopping or leave the brakes off so that the aircraft may be pushed clear.

ENGINE FEATHERING AND FIRE DRILL

Note: Before practice feathering, leave throttle at idle for a minimum of 20 secs.

1	Power on Live Engine	CHECK	1
2	Throttle	CLOSE	2
3	Propeller	FEATHER	3
4	Mixture	ICO	4
5	Gear and Flaps	UP	5

ACADEMY

PA34-200T
CHECK LIST

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09/08/01

CROSSFEED DRILL AFTER ENGINE FAILURE

1	Fuel Selector (Dead Side)	OFF	1
2	Fuel Selector (Live Side)	CROSSFEED	2
3	Electrical Fuel Pump	AS REQUIRED	3

UNFEATHERING DRILL

1	Fuel Selector	ON	1
2	Electrical Fuel Pump	OFF	2
3	Throttle	SET	3
4	Propeller	SET	4
5	Mixture	RICH	5
6	Magneto Switches	ON	6
7	Engine Starter/Primer	ENGAGE	7
8	Oil Pressure	CHECK	8
9	Power	SET	9
10	Ammeter	CHECK	10
11	Gyro Pressure	CHECK	11

GEAR EMERGENCY LOWERING

1	Airspeed	CHECK MAX 84kts	1
2	Gear Selector	DOWN	2
3	Gear Emergency Selector	PULL	3
4	Gear Indicator Lights	CHECK 3 GREENS	4

ELECTRICAL SYSTEM - ALTERNATOR FAILURES

- ***Printed in clear text.***

In order to make a checklist easy to read, the size and clarity of the text must be sufficient for it to be read in poor lighting conditions by a pilot whose workload is high.

The Use of Checklists.

Pilots must be thorough and conscientious in carrying out checks, and should be aware of the common errors which may be made when working through a checklist:

If, after strapping yourself into the cockpit prior to a flight, you discover that you cannot locate your checklist, do not continue your vital pre take-off checks from

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memory alone. Accept that you have committed an error, unstrap, disembark from the aircraft, and retrieve your checklist.

Beware of losing your place in the checklist, and of returning to the wrong location. If you commit this error, an important item may be missed.

During your flying training, take care to read out all the vital pre-take-off checks clearly and crisply, so that your instructor is aware that you are carrying out the checks in the correct manner.

If you are interrupted in the checks, recommence them by moving one item back in the checklist.

Do not labour the checks. You must not be over-hasty in carrying them out, but nor should you be painfully slow.

A major source of error in carrying out routine checks is that checklist items may be responded to automatically rather than diligently. It is tempting for pilots to regard a rapid reading over of checklist items as indicative of their skill and familiarity with the aircraft, but, if checks are dealt with in this automatic way, it is very easy for a pilot to see on the aircraft's instrument panel, or in the operation of a control, what he expects to see, rather than the reality of the situation. Pilots must be aware of this tendency and devote particular care to carrying out checks.

If the checking sequence is interrupted by an external event (a radio call for example), it is easy for an item from the checklist to be missed. If you are ever interrupted while carrying out your checks, always recommence the checking sequence by moving at least one item back from the item you had reached when the interruption intervened.

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Representative PPL - type questions to test your theoretical knowledge of The Cockpit.

1. Sitting below the eye datum point:

    a. Prevents the pilot's head from coming into contact with the cockpit roof
    b. Means that part of the undershoot may be obscured, on the approach
    c. Allows faster egress from the cockpit in an emergency
    d. Means that part of the overshoot may be obscured, on the approach

2. If a pilot is interrupted when carrying out the pre-take-off checks, he should:

    a. Recommence the checks from the item in the checklist reached when the interruption occurred
    b. Recommence the checks from the beginning of the checklist
    c. Recommence the checks beginning with an item located one step back in the checklist from the item reached when the interruption occurred
    d. Recommence the checks beginning with an item located one step further on in the checklist from the item reached when the interruption occurred

3. Which of the following is NOT a basic consideration governing the way controls should be both designed and arranged?

    a. Controls should be standardised in location and sense of use from one aircraft to the other
    b. Controls should be standardised between aircraft, in terms of their shape and materials only
    c. Controls having different functions should both look and feel different
    d. Important controls should be located in easily reached and unobstructed positions

4. You are preparing for a training flight with an instructor and cannot find your checklist. You should:

    a. Perform the checks from memory
    b. Use a checklist for a different aircraft type
    c. Take time to find the checklist even at the risk of missing part of your airborne time
    d. Rely on the instructor to point out anything that you might have missed

5. Which of the following occur(s) when a pilot is sitting too high in a cockpit?

i) Good downward outside view
ii) Poor view of instruments
iii) Upwards outside view obstructed

a. i) only
b. i) and ii) only
c. i), ii) and iii)
d. ii) and iii) only

6. An analogue display is generally better than a digital display for showing which sort of data?

a. Quantitative
b. Qualitative
c. Numerical
d. Subjective

7. A standard "T" layout has the artificial horizon or attitude indicator at the centre. Which of the following is NOT included in the rest of the "T"?

a. The altimeter
b. The airspeed indicator
c. The direction indicator
d. The compass

8. Which of the following actions does NOT constitute a pilot error when carrying out checks from a check list?

a. Carrying out checks diligently and expeditiously
b. Carrying out checks from the list slowly and laboriously
c. Automatically responding to the check list without carrying out the check
d. Missing out items

Question	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Answer								

The answers to these questions can be found at the end of this book.

DEFINITIONS

GLOSSARY OF TERMS

This glossary of terms is issued as a reference for some of the words and phases associated with the subject of Human Performance & Limitations. It is intended to act as a quick reference for those students who are not familiar with some of the technical terms used in the subject.

Accommodation: The changing of the shape of the lens of the eye, through the ciliary muscles, to achieve the final focussing onto the retina.

Acuity: It is the ability to discriminate at varying distances. An individual with an acuity of 20/20 vision should be able to see at 20 feet that which the so-called normal person is capable of seeing at this range

Adrenaline: A stress hormone which causes a massive release of sugar reserves from the liver and prompts the body into certain actions aimed primarily to assist survival.

Alveoli: The final division in the lungs; very fine sac-like structures where blood in the alveolar capillaries is brought into very close proximity with oxygen molecules. Under the effect of a pressure gradient, oxygen diffuses across the capillary membrane from the alveolar sac into the blood.

Anaemia: This occurs when cells of the various tissues are deprived of oxygen through insufficient haemoglobin or red blood cells.

Angina: The pain developing in the chest, or sometimes the neck, shoulder or arms, which is caused by a narrowing of the coronary arteries carrying blood to the heart muscle. The narrowing or gradual blockage of the coronary arteries results in insufficient blood reaching the muscle and the effect is to deprive part of the muscular pump of oxygen when demands are placed on it by exertion or emotion.

Anthropometry: The study of human measurement.

Anxiety: A state of apprehension, tension and worry. It can also be a vague feeling of danger and foreboding.

Aorta: The main artery leaving the heart’s left ventricle before dividing into smaller arteries to carry the oxygenated blood around the body.

Arousal: The measure of the Human Being’s readiness to respond. It can be said to be the general activation of the physiological systems.

Attention: Attention is the deliberate devotion of the cognitive resources to a specific item.

Atrium: The left and right atria (auricles) are the upper chambers of the heart. The right atrium collects venous blood (de-oxygenated) and passes it to the right ventricle from where it is pumped into the lungs to receive oxygen. The left atrium collects the oxygenated blood from the lungs and passes it to the left ventricle from where it can be passed around the body to the various tissues.

Audiogram: This instrument measures hearing.

Auto-kinesis: This occurs in the dark when a static light may appear to move after being stared at for several seconds.

Autonomic nervous system: The nervous system controlling many of the functions essential to life, such as respiration, Arterial pressure gastrointestinal motility, urinary output, sweating, body temperature and the General Adaption Syndrome (sometimes known as the Fight or Flight Response) over which we normally have no conscious control.

Barotrauma: Pain caused by the expansion and contraction, due to outside pressure changes of air trapped in the cavities of the body, notably within the intestines, middle ear, sinuses or teeth. Barotrauma can cause discomfort or extreme pain sufficient to interfere with the operation of the aircraft.

Bends: Experienced during decompression sickness when nitrogen bubbles affect the joints causing pain.

Blind Spot: The site on the retina where the optic nerve enters the eyeball. Having no light sensitive cells in this area, any image on this section of the retina will not be detected.

Blood Pressure: Blood pressure as measured in mm Hg at a medical examination is given as two figures eg 120/80. The first (highest) figure is the systolic pressure which is the pressure at systole when the left ventricle is contracting to send the oxygenated blood around the body to the various tissues. The lower figure is the diastolic pressure which is the constant pressure in the system even when the heart is not contracting.

Body Mass Index (BMI): A measure of any excess fatty tissue in the body. The Body Mass Index relates height to weight by the formula:

BMI = weight in kilogrammes ÷ (height in metres)^2

Bronchus: A division in the respiratory system. Air drawn into the nose and mouth is passed first through the Trachea, which then divides into two large airways, the left and right bronchi. The bronchi carry the air into the left and right lungs before they divide into smaller airways eventually terminating in the alveoli.

Capillary: The smallest division of the blood circulation system. They are very thin walled blood vessels in which oxygen is in close proximity to the tissues and unlatches from haemoglobin. The oxygen molecules diffuse down a pressure dependant gradient across the cell walls into the respiring tissues. Carbon dioxide and water is picked up in exchange, and the capillary blood passes on into the veins.

Carbonic Acid: Carbon dioxide is produced in the tissues as the result of the oxidation of foodstuffs to provide energy. This carbon dioxide is carried in the blood in solution but largely in chemical combination as carbonic acid.

Cardiac Arrest: State in which the heart ceases to pump blood around the body.

Central Vision: Vision at the Fovea. Only at this part of the retina is vision 20/20 or 6/6.

Cerebellum: Second and smaller division of the brain. Responsible for receiving information from all nerve endings including the semi-circular canals in the inner ear.

Cerebrum: A part of the fore-brain which contains the cells that perform the functions of memory, learning and other higher mental powers.

Chokes: The difficulty in breathing experienced as a result of decompression sickness.

CHIRP: Confidential Human Factors Incident Reporting Programme is a scheme which enables all Civilian Aircrew and Air Traffic Control personnel to report their errors in complete confidence to the RAF Institute of Aviation Medicine. The CHIRP scheme was initiated and sponsored by the Civil Aviation Authority.

Ciliary muscles: The ciliary muscles push and pull the lens of the eye to achieve the final focussing. - see also accommodation above.

Circadian Rhythms: Many physiological processes in the body exhibit regular rhythmic fluctuations, and they occur whether one is asleep or is kept awake. These rhythms are controlled not by reactions to the external environment but internally. The most common rhythms exhibited by man and other organisms have periodicities of, or about, 24 hours. These rhythms are termed “circadian rhythms”, from the Latin “circa” - about and “dies” - day.

Circadian Disrhythmia: Disruption of the Circadian Rhythms (see above).

Co-action: Working in parallel to a common goal.

Cochlea: That part of the inner ear concerned with hearing. Vibrations in the air, sounds, are passed to the eardrum causing it to vibrate. This vibration is passed across the middle ear by a series of small bones to the fluid-filled cochlea of the inner ear. The cochlea contains a sensitive membrane which responds to vibrations and generates the nerve impulses which the brain interprets as sounds.

Conductive Deafness: See hearing loss.

Cones: Light sensitive cells situated on the retina at the back of the eye which are sensitive to colour. These cells convert light into nerve impulses that travel up the optic nerve to the brain where the visual picture is built up.

Confirmation Bias: In decision making, once a decision is made, there is a natural tendency to stay with that decision. Here a subject will often take a small piece of information and use it to “confirm” the process that is already in place even to the extent of ignoring other more compelling evidence suggesting a flaw in the plan.

Coriolis Effect: An illusion of a change in the turn rate due to a sudden movement of the head.

Cornea: A transparent focussing layer at the front of the eyeball.

Coronary Thrombosis: See Heart Attack.

Cortex: That part of the brain which receives impulses from the auditory nerve and translates them into sound patterns.

Cortisol (Cortisone): Substance released during 2nd phase of General Adaption Syndrome to convert fats to sugar thus prolonging body mobilisation in face of perceived stress/threat.

Cyanosis: The development of a blue colour in those parts of the body in which the blood supply is close to the surface, the lips or under the fingernails, caused by a lack of oxygen in the blood and a consequent shortage of oxy-haemoglobin. Cyanosis is one of the signs of Hypoxia.

Diaphragm: A muscular and tendinous sheet separating the thorax and abdomen. Movement of the diaphragm helps to reduce the pressure in the chest, drawing air into the lungs. In the process of breathing out the diaphragm is relaxed.

Diffusion: The movement of particles from regions of high concentration to regions of lower concentrations.

ECG: Electrocardiogram, a device for measuring the synchronisation of the brain's electrical impulses with the beating of the heart (pulse rate).

EEG: Electroencephalogram, a device to measure the electrical activity of the brain.

EMG: Electromyogram, used to measure the electrical activity associated with the contraction and relaxation of muscles.

Endolymph: The fluid which fills the inner ear and in particular the three semi-circular canals which are used to detect angular movement and provide balance cues for the brain.

Electrolytes: Electrolyte is a chemical capable of carrying or conducting an electrical charge in solution. The body relies on the presence of electrolytes to carry nerve impulses and to maintain cell metabolism.

EOG: Electroculogram, a device to measure eye movement using electrodes attached to the outer corners of the eyes.

Episodic Memory: A part of long-term memory storing episodes/events in our lives.

Ergonomics: The principle of design which ensures that the job required should be fitted to the man rather than the man to the job.

Expiratory Reserve Volume: The amount of air that can be still exhaled by forceful expiration after the end of the normal tidal expiration.

Faults: A category of errors. The action satisfies the operator’s intent, but the intent itself was incorrect.

Fight or Flight: See Automatic Nervous System.

Formication: A creeping sensation felt on the skin as a result / symptom of hypoxia.

Fovea: That part of the retina, composed only of cones, which is the most central part of the retina. only at the fovea is there 6/6 or 20/20 vision. It is the area of highest visual acuity and away from the fovea the acuity declines rapidly.

General Adaption Syndrome (GAS): the term used to describe the mechanism by which an individual reacts to an outside perceived threat.

Gestalt Theory: From the German word gestalt meaning “shape”. This theory of learning proposes that any individual’s understanding of the world results from sorting out and combining multiple cues perceived in the environment until a “coherent whole” appears that is acceptable according to the individual’s standards as regards the world.

Glaucoma: A disease of the eye which causes a pressure rise of the liquid within the eye. Glaucoma can cause severe pain and even blindness. Glaucoma exists in two forms: Acute and Chronic.

Habituation: A term for Sensory Adaption. It is also sometimes used when referring to Environmental Capture (an error brought upon by habit).

Haemoglobin: Haemoglobin is made up of a combination of protein and a chemical called Heme which has an atom of iron contained in the middle of the molecule. It is found in the red blood cells and has the property of uniting with oxygen in a reversible manner to form oxy-haemoglobin. The combination will release the oxygen again to a gas mixture which contains little, or no, oxygen. Haemoglobin has a much greater affinity for CO (carbon monoxide) than for oxygen, therefore the presence of carbon monoxide in the air will cause a reduction in the amount of oxygen that may be carried in the blood.

Hearing Loss: Caused by a number of factors. A breakdown of the eardrum / ossicles system is Conductive Deafness. The loss of some hearing as the natural consequence of growing old is known as Presbycusis. Hearing loss caused by damage to the sensitive membrane in the cochlea by the intensity and duration of loud noises is called “Noise Induced Hearing Loss”(NIHL).

Heart Attack: Also known as myocardial infarction. The blockage of one of the coronary arteries, usually by a clot, will deprive some of the heart muscle of an oxygen supply. The effects are dramatic, often with severe chest pain, collapse, and sometimes complete cessation of the heart. (See also Infarct)

Homeostatis: The process of the body maintaining physiological equilibrium through organs and internal control mechanisms in spite of varying external conditions.

Hydrostatic Variation: The difference of the blood pressure in the legs and lower body and the blood pressure at the heart.

Hypermetropia: Long sightedness. A shorter than normal eye results in the image being formed behind the retina. Images of close objects will become blurred.

Hypertension: High blood pressure.

Hyperventilation: Over-breathing, causing changes in the acid / base balance of the body. Can be caused not only by Hypoxia but also by anxiety, motion sickness, vibration, heat, high ‘g’ or shock.

Hypoglycemia: Low sugar content of the blood normally caused by fasting or not eating regularly.

Hypovigilance: Sleep patterns showing on an EEG during human activity.

Hypoxia: Inadequate oxygen supply. In mild cases the symptoms may hardly be noticed but as the hypoxia increases the symptoms become more severe, leading in some cases to unconsciousness and even death.

Iconic memory: The visual sensory store. Physical stimuli which are received by the sensory receptors (e.g. eyes, ears etc) can be stored for a brief period of time after the input has ceased. The iconic memory only lasts for about 0.5 to one second but it does enable us to retain information for a brief period of time until we have sufficient spare processing capacity to deal with the new input.

Infarct: (Infarction): The death of a portion of a tissue or organ due to the failure of the blood supply. Hence the death of part of the heart muscle due to a failure of some of the coronary artery supply is also known as a “coronary infarction”.

Insomnia: Inability to gain sufficient sleep. Divided into Clinical Insomnia and Situational Insomnia

Inspiratory Reserve Volume: The extra volume of air that can be inhaled over and beyond the normal tidal volume.

Leans: Experienced when the vestibular apparatus of the ear has given an incorrect assessment of attitude leading to the senses of the pilot giving, for example, a “banking sensation” when the visual picture will tell him that he is “straight and level”.

Long Sightedness: See hypermetropia.

Mental Schemas: Mental representations of categories of objects, events and people.

Mesopic Vision: Vision through the functioning of both the Rods and Cones.

Metabolism: The chemical processes in a living organism producing energy and growth.

Metacommunications: The term that covers communication in its complete sense embracing everything from body language / facial expression to simple voice communication to enable a transfer of information to take place.

Microsleeps: Very short periods of sleep lasting from a fraction of second to two to three seconds.

Myopia: Short sightedness. A longer than normal eye results in image forming in front of the retina. If accommodation cannot overcome this then distant objects will be out of focus.

Narcolepsy: The tendency of an individual to fall asleep even when in sleep credit can even occur when driving or flying. Narcolepsy is a recognised disorder and is clearly undesirable in any aircrew.

Neuron: A nerve cell

NIHL: See Hearing loss.

Oculogravic Illusion: Visually apparent movement of a forward object that is actually in a fixed position relative to the observer due to the displacement of the Otoliths.

Orthodox sleep: Another term for slow wave sleep.

Ossicles: The small bones in the middle ear which transmit the vibration of the eardrum to the cochlea of the inner ear.

Paradoxical Sleep: Another term for REM Sleep for although the person is certainly asleep the brain activity is very similar to that of someone who is fully awake.

Parasympathetic Nervous System: See Autonomic nervous system.

Percept: The immediate interpretation of the information in the sensory store. It is not necessarily a complete representation of the information.

Perception: The active process through which people use knowledge and understanding of the world to interpret sensations as meaningful experiences.

Peripheral Vision: Vision emanating away from the Fovea and from the rods cell-receptors of the eye.

Photopic Vision: Vision through the functioning of the Cone light-sensitive cells of the eye.

Presbycusis: See Hearing loss.

Presbyopia: A form of long sightedness caused by the lens of the eye losing its elasticity with age. The loss of elasticity means that the lens can no longer accommodate fully and will result in close objects becoming blurred. A common condition in those more than 45 years of age, but easily corrected with a weak convex lens.

Psychosomatic: Refers to a psychological reaction to an outside stimulus causing physiological changes or changes. It refers to the interrelationships of the mind and body.

Pulmonary: Referring to the lungs. Hence the pulmonary artery takes blood from the heart to the lungs and the pulmonary vein carries oxygenated blood from the lungs back to the heart.

Regression: A symptom of stress in which correct actions are forgotten and substituted for procedures learnt in the past.

REM: (Rapid Eye Movements) A term used in sleep studies to define a stage of sleep. In REM sleep the EEG becomes irregular and the EOG shows the eyes rapidly darting back and forth whilst the EMG shows the muscles to be relaxed. It is suggested that during REM sleep the memory is strengthened and organised. Sometimes referred to as Paradoxical Sleep.

Residual Volume: The volume of air remaining in the lungs even after the most forceful expiration

Retina: A light sensitive screen on the inside of the eye to which images are focussed. The retina has light sensitive cells, rods and cones, which convert the image into nerve impulses which are interpreted by the brain.

Rods: Light sensitive cells on the retina. They are sensitive to lower levels of light than the cones and are not sensitive to colour. To adapt completely to dark conditions will take the rods about 30 minutes and their adaption can be destroyed by even a transitory bright light.

Saccade: The eye cannot be moved continuously and smoothly when searching for a target, but moves in jerks, known as saccades, with rests between them. The external world is sampled only during the resting periods. An eye movement / rest cycle takes about one third of a second, which means that the amount of the external world that can be examined in detail is strictly limited.

Scotopic Vision: Vision through the functioning of the rod light-sensitive cells of the eye.

Semantic Memory: A part of long-term memory storing information as to general knowledge of the world.

Semicircular canals: The organs of the inner ear set in three planes at right angles to each other, which detect angular acceleration.

Skill: is an organised and co-ordinated pattern of activity. It may be physical, social, linguistic or intellectual.

Slips: A category of errors. Slips do not satisfy the operator's intent although the intent was correct.

Somatosensory system: Pressure and position nerve receptors distributed throughout the body that provide information, for example, on the orientation of the seat on which we sit. The somatosensory system along with the vestibular apparatus and our vision enables us to maintain an image of our spatial orientation.

Somnambulism: Sleep Walking.

Somniloquism: Talking in one's sleep.

Staggers: Experienced when suffering from decompression sickness as nitrogen bubbles affect the blood supply to the brain causing the sufferer to lose some mental and body control functions.

Stapes (or Stirrup): The inner bone of the Ossicles.

Stroboscopic Effect: A flickering effect of light and in Aviation is often caused by a propellor or, in the case of a helicopter, the rotor blade turning and cutting the sunlight.

Stereopsis: The ability to judge depth visually due to the principle that near objects produce images on each retina that are more different from one another than distant objects.

Stroke: A term used to describe the effects of a blockage of one of the arteries to the brain. The disruption of blood flow, and therefore oxygen supply to that part of the brain will cause a failure in the ability of the brain to control a particular part of the body. Depending on the site affected, the results could be paralysis, loss of speech, loss of control of facial expression.

Subcutaneous: An adjective meaning below or under the skin.

Sympathetic Nervous System: See Autonomic Nervous System.

Synapse: The connection between two neurons.

Syncope: Fainting through a fall in blood pressure.

Tidal Volume: The volume of air inhaled and exhaled with each normal breath.

Time of Useful Consciousness (TUC): The amount of time an individual is able to perform useful flying duties in an environment of inadequate oxygen.

Thrombus: A clot of blood which can stop blood flow to any organ. If the blockage is in one of the Coronary Arteries then a heart attack can result or if in an artery to the brain then the result will be a stroke.

Trachea: The main airway leading from the nose / mouth into the chest cavity. It is a cartilage reinforced tube which divides into two bronchii which deliver air to the left and right lungs.

Ventricles: The two largest and most muscular divisions of the heart. The left ventricle, when it contracts, sends the blood around the body. The right ventricle passes blood from the heart to the lungs to be recharged with oxygen.

Vestibular Apparatus: The combination of the semicircular canals and the otoliths. The function of the vestibular apparatus is to provide data to the brain that enables it both to maintain a model of spatial orientation and to control other systems that need this information.

Visual Cortex: That part of the brain which receives the electrical charges from the Optic Nerve of the eye.

Visual Field: Visual Field comprises of both the Central and Peripheral vision.

Visual Perception Cascade: The reaction time from visual input, brain reaction, perception to recognition. In perfect conditions this takes approximately 1 second.

Vigilance (state of): The degree of activation of the central nervous system. This can vary from deep sleep to extreme alertness.

JAR-FCL PPL THEORETICAL KNOWLEDGE SYLLABUS

HUMAN PERFORMANCE AND LIMITATIONS

The table below contains the principal topics and subtopics from the current outline syllabus for the theoretical examination in Human Performance and Limitations for the Private Pilot's Licence, as published in JAR-FCL 1. Syllabuses may be modified, so always check the latest examination documentation from your national civil aviation authority, or from JAR-FCL/EASA.

HUMAN PERFORMANCE AND LIMITATIONS	
BASIC PHYSIOLOGY	
Concepts:	composition of the atmosphere; the gas laws; respiration and blood circulation.
Effects of partial pressure:	effect of increasing altitude; gas transfer; hypoxia (symptoms; prevention); cabin pressurisation; effects of rapid decompression (time of useful consciousness; the use of oxygen masks and rapid descent); hyperventilation (symptoms; avoidance); effects of accelerations.
Vision:	physiology of vision; limitations of the visual system (vision defects; optical illusions; spatial disorientation; avoidance of disorientation).
Hearing:	physiology of hearing; inner ear sensations; effects of altitude change; noise and hearing loss (protection of hearing); spatial disorientation (conflicts between ears and eyes; prevention of disorientation).
Motion sickness:	causes; symptoms; prevention.
Flying and health:	medical requirements; effect of common ailments and cures (colds; stomach upsets; drugs, medicines, and side effects; alcohol; fatigue); personal fitness; passenger care; scuba diving – precautions before flying.
Toxic hazards:	dangerous goods; carbon monoxide from heaters.
BASIC PSYCHOLOGY	
The information process:	concepts of sensation; cognitive perception (expectancy; anticipation; habits).
The central decision channel:	mental workload, limitations; information sources (stimuli and attention; verbal communication); memory and its limitations; causes of misinterpretation.
Stress:	causes and effects; concepts of arousal; effects on performance; identifying and reducing stress.
Judgement and decision making:	Judgement and decision making; concepts of pilots' judgement; psychological attitudes (behavioural aspects); risk assessment (development of situational awareness).

ANSWERS TO HUMAN PERFORMANCE QUESTIONS

ANSWERS TO THE HUMAN PERFORMANCE QUESTIONS

Chapter 1 Introduction

Question	1	2	3	4	5	6
Answer	b	d	a	b	d	a

Chapter 2 The Atmosphere

Question	1	2	3	4	5	6	7
Answer	c	c	a	d	b	a	c

Chapter 3 The Human Body

Question	1	2	3	4	5	6	7	8	9	10
Answer	c	a	c	d	c	b	a	c	d	b

Chapter 4 The Effects of Partial Pressure

Question	1	2	3	4	5
Answer	c	d	a	d	b

Chapter 5 The Eye

Question	1	2	3	4	5	6	7	8	9	10	11
Answer	d	b	b	c	a	b	d	a	c	b	c

Chapter 6 The Ear

Question	1	2	3	4	5	6	7	8	9	10	11	12
Answer	b	c	a	d	c	d	a	d	c	c	c	d

Chapter 7 Flying and Health

Question	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Answer	d	b	c	a	b	d	c	c	b	a	b	b	d	c	c	a

ANSWERS TO THE HUMAN PERFORMANCE QUESTIONS

Chapter 8 The Information Process

Question	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
Answer	**c**	**a**	**c**	**d**	**b**	**a**	**b**	**d**	**c**	**c**	**a**	**d**	**b**	**a**

Chapter 9 Judgement and Decision Making

Question	**1**	**2**	**3**	**4**
Answer	**d**	**b**	**b**	**a**

Chapter 11 Stress

Question	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Answer	**b**	**d**	**c**	**b**	**c**	**a**	**c**	**a**	**c**

Chapter 12 The Cockpit

Question	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Answer	**b**	**c**	**b**	**c**	**c**	**b**	**d**	**a**

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