

II.A. Aeromedical Factors

References: FAA-H-8083-3; AIM; AC 67-2

Objectives	The student should exhibit knowledge regarding aeromedical factors as required in the PTS.
Key Elements	<ol style="list-style-type: none">1. IM SAFE – Self Checklist2. Trust the instruments3. Carbon Monoxide is 200x more likely to bond with blood than oxygen4. Drugs + Alcohol + Flying = Very Bad
Elements	<ol style="list-style-type: none">1. Obtaining an Appropriate Medical Certificate2. Hypoxia3. Hyperventilation4. Middle Ear and Sinus Problems5. Spatial Disorientation6. Motion Sickness7. Carbon Monoxide Poisoning8. Fatigue and Stress9. Dehydration10. Alcohol and other Drugs11. Nitrogen and Scuba Diving12. IM SAFE
Schedule	<ol style="list-style-type: none">1. Discuss Objectives2. Review material3. Development4. Conclusion
Equipment	<ol style="list-style-type: none">1. White board and markers2. References
IP's Actions	<ol style="list-style-type: none">1. Discuss lesson objectives2. Present Lecture3. Ask and Answer Questions4. Assign homework
SP's Actions	<ol style="list-style-type: none">1. Participate in discussion2. Take notes3. Ask and respond to questions
Completion Standards	The student has the ability to explain different aeromedical factors, and their importance to flying and possible effects during flight.

Instructors Notes:

Introduction:

Attention

Interesting fact or attention grabbing story

To be safe in the airplane requires knowledge of the possible factors that could have pretty rough consequences if we were not aware of them and how to treat them. Hypoxia can result in symptoms of euphoria and the inability to make any sort of rational decision – which is obviously not a good thing while you’re trying to fly a plane. (There are many good hyperbaric chamber/hypoxia videos on you tube)

Overview

Review Objectives and Elements/Key ideas

What

Aeromedical factors involve a number of health factors and physiological effects that have great effects on pilots in flight. Some are minor, while others require special attention to ensure safety and survival.

Why

As a pilot, it is important to stay aware of the mental and physical standards required for the type of flying done. In some cases, these factors can lead to in-flight emergencies.

How:

1. Obtaining an Appropriate Medical Certificate

- A. Issued after a routine medical examination which by administered only by FAA-designated doctors called Aviation Medical Examiners (AME)
- B. FAA Directory of AMEs (<http://www.faa.gov/pilots/amelocator/>)
 - i. FSDOs
 - ii. FSSs
 - iii. FAA Offices
- C. Student Pilot
 - i. Must request a combined medical/student pilot certificate, which functions as a student pilot certificate once signed by the AME
- D. Medical Certificate with a Possible Medical Deficiency
 - i. Even with a medical deficiency, a medical certificate can be issued
 - a. Operating limitations may be imposed, depending on the nature of the deficiency
 - b. Obtain assistance from an AME and the local FSDO
 - The assistance is only available on request
- E. Regulation
 - i. Once a medical is obtained, it is self regulating
 - a. Can you fly with an injury, possible sickness?
 - It’s the pilot’s judgment (be safe, and conservative)

2. Hypoxia

- A. Hypoxia means “reduced oxygen” or “not enough oxygen”
 - i. The most concern is with getting enough oxygen to the brain, since it is particularly vulnerable to oxygen deprivation
 - ii. Hypoxia can be caused by several factors including:
 - a. An insufficient supply of oxygen

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- b. Inadequate transportation of oxygen
 - c. Inability of the body tissues to use oxygen
- B. Hypoxic Hypoxia
 - i. A result of insufficient oxygen available to the lungs
 - ii. A blocked airway or drowning are examples of how the lungs can be deprived of oxygen
 - iii. For Pilots: The reduction in partial pressure of oxygen at high altitude is a common example
 - a. Partial Pressure is the amount of pressure that a single gas (out of a mixture) contributes to the total pressure
 - iv. Although the percentage of oxygen in the atmosphere is constant with changes in altitude, the partial pressure decreases as altitude increases
 - a. As you ascend, the percentage of each gas remains the same, but the molecules no longer have the pressure required to drive oxygen into the respiratory system
 - b. The decrease of oxygen molecules at sufficient pressure leads to hypoxic hypoxia
- C. Hypemic Hypoxia
 - i. Occurs when the blood is not able to take up and transport sufficient oxygen to the cells in the body
 - ii. Hypemic means “not enough blood”
 - iii. This type of hypoxia is a result of oxygen deficiency in the blood
 - iv. Possible Causes:
 - a. Not enough blood volume
 - Can be caused by severe bleed or blood donation
 - b. Certain blood diseases, such as anemia
 - c. Hemoglobin, the molecule that transports oxygen, is unable to bind oxygen molecules
 - d. Carbon monoxide poisoning
- D. Stagnant Hypoxia
 - i. Stagnant means “not flowing;” stagnant hypoxia results when the oxygen rich blood in the lungs isn’t moving to the tissues that need it
 - a. Ex. An arm or leg going to sleep because the blood flow has been restricted
 - ii. This type of hypoxia can result from:
 - a. Shock
 - b. The heart failing to pump blood effectively
 - c. A constricted artery
 - iii. During flight, stagnant hypoxia can occur when pulling excessive positive G’s
 - iv. Cold temperatures can also decrease the blood supplied to extremities
- E. Histotoxic Hypoxia
 - i. The inability of the cells to effectively use oxygen
 - a. “Histo” refers to tissues or cells, and “Toxic” means poison
 - ii. In this case, oxygen is being transported to the cells, but they are unable to use it
 - iii. Causes:
 - a. Alcohol and other drugs, such as narcotics and poison
 - Drinking an ounce of alcohol is equivalent to an additional 2,000’ of altitude
- F. Symptoms of Hypoxia
 - i. The first symptoms are euphoria and a carefree feeling. With increased oxygen starvation, the extremities become less responsive and flying becomes less coordinated.
 - ii. As it worsens, vision narrows, concentration and instrument interpretation become difficult
 - iii. Common symptoms include:
 - a. Cyanosis (blue fingernails and lips)
 - b. Headache
 - c. Decreased reaction time

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- d. Impaired judgment
- e. Euphoria
- f. Visual Impairment
- g. Drowsiness
- h. Lightheaded or dizzy sensation
- i. Tingling in fingers or toes
- j. Numbness
- k. Even with all of these symptoms, the effects of hypoxia can cause a pilot to have a false sense of security and be deceived into believing that everything is normal (euphoria)

G. Useful Consciousness

- i. Describes the maximum time the pilot has to make rational, life saving decisions and carry them out at a given altitude without supplemental oxygen
- ii. As altitude increases above 10,000 ft, the symptoms of hypoxia increase in severity, and the time of useful consciousness rapidly decreases

Altitude	Time of Useful Consciousness
45,000 ft MSL	9 to 15 seconds
40,000 ft MSL	15 to 20 seconds
35,000 ft MSL	30 to 60 seconds
30,000 ft MSL	1 to 2 minutes
28,000 ft MSL	2 ½ minutes to 3 minutes
25,000 ft MSL	3 to 5 minutes
22,000 ft MSL	5 to 10 minutes
20,000 ft MSL	30 minutes or more

H. Treatment

- i. Flying at lower altitudes
 - a. Emergency Decent
- ii. Use supplemental oxygen immediately

3. Hyperventilation

- A. Occurs when an individual is experiencing emotional stress, fright, or pain, and the breathing rate and depth increase
 - i. The result is an excessive loss of carbon dioxide from the body, which can lead to unconsciousness while the respiratory system attempts to override your actions and regain control of breathing
- B. Pilots encountering a stressful situation may unconsciously increase their breathing rate
 - i. If flying at higher altitudes, with or without oxygen, a pilot may have a tendency to breathe more rapidly than normal, which can lead to hyperventilation
- C. Since many symptoms of hyperventilation are similar to those of hypoxia, it is important to correctly diagnose and treat the proper condition.
- D. Common Symptoms:
 - i. Headache
 - ii. Decreased reaction time
 - iii. Impaired judgment
 - iv. Euphoria
 - v. Visual Impairment
 - vi. Drowsiness
 - vii. Lightheaded or dizzy sensation
 - viii. Tingling in fingers and toes

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- ix. Numbness
- x. Pale, clammy appearance
- xi. Muscle spasms

E. Treatment

- i. Involves restoring the proper carbon dioxide level in the body
- ii. If using supplemental oxygen, check the equipment and flow rate to ensure the symptoms are not hypoxia related
- iii. Breathing normally is both the best prevention and the best cure for hyperventilation
- iv. Breathing into a paper bag or talking aloud helps to overcome hyperventilation
- v. Recovery is usually rapid once the breathing rate is returned to normal
- vi. Because hyperventilation and hypoxia symptoms are so similar, if unsure, it is best to treat the hypoxia as it the more threatening situation

4. Middle Ear and Sinus Problems

A. Middle Ear Problems

- i. Explanation
 - a. There is a difference between the pressure of the air outside the body and the air inside the middle ear and nasal sinuses
 - b. The middle ear is a small cavity located in the bone of the skull
 - Normally, the pressure difference between the middle ear and the outside world are equalized by the Eustachian Tube
 - a A tube leading from inside each ear to the back of the throat on each side
 - b These tubes are usually closed, but open during chewing, yawning or swallowing to equalize pressure
- ii. Symptoms
 - a. Pain is the primary indicator
 - The pain can be excessive and damage can be done to the eardrums if the pressure differential is too great
 - b. Temporary reduction in hearing sensitivity
- iii. Relation to flying
 - a. During a climb, if the air pressure in the Eustachian tube cannot equalize (remains at ground level), while the pressure on the outside of the eardrum decreases the eardrum will bulge outward resulting in discomfort
 - b. During a descent, the reverse happens: as the aircraft descends, the pressure on the outside of the eardrum increases while the pressure in the Eustachian tube remains at altitude, resulting in the eardrum bulging inward causing discomfort
 - c. Excessive pressure in either situation can result in pain and a ruptured ear drum
- iv. Treatment
 - a. If minor, chew gum or stretch the jaw to attempt to equalize pressure
 - b. Pinch the nostrils, close the mouth, and blow slowly and gently in the mouth and nose
 - This forces air into the Eustachian tube allowing the pressure to equalize
 - It may not be possible to equalize the pressure in the ears if a pilot has a cold, an ear infection, or sore throat
 - This treatment is more helpful in a decent
 - a Be cautious in a climb, forcing air into the Eustachian tube may add more pressure and force the eardrum farther outward leading to increased pain
 - c. If experiencing minor congestion, nose drops or nasal sprays may reduce painful ear blockage

B. Sinus Problems

- i. Explanation

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- a. Air pressure in the sinuses equalizes with the pressure in the cockpit through small openings that connect the sinuses to the nasal passages
- b. An upper respiratory infection (cold or sinusitis) or a nasal allergic condition can produce enough congestion around an opening to slow equalization
- ii. Symptoms
 - a. Pain over the sinus area (pain can become excessive)
 - b. Some sinus blocks can make the upper teeth ache
 - c. Bloody mucus may discharge from the nasal passages
- iii. Relation to flying
 - a. As the difference in pressure between the sinus and the cockpit increases, congestion may plug the sinus' openings
 - b. The "sinus block" occurs most frequently during descents
- iv. Treatment
 - a. Slow decent rates can reduce the associated pain
 - b. Do not fly with sinus problems (avoid the situation entirely)

5. Spatial Disorientation

- A. Explanation
 - i. Orientation is the awareness of the position of the aircraft and of oneself in relation to a specific reference point
 - ii. Disorientation is the lack of orientation
 - iii. Spatial Disorientation refers to the lack of orientation with regard to the position, attitude, or movement of the airplane in space
 - iv. The body uses three systems to ascertain orientation and movement in space
 - a. Visual: The eye, by far the largest source of information
 - b. Postural: The sensation of position, movement, and tension perceived through nerves, muscles, and tendons
 - c. Vestibular System: A very sensitive motion sensing system located in the inner ears. It reports head position, orientation, and movement in three-dimensional space
 - v. All of this info comes together in the brain, and most of the time, the three streams of information agree, giving a clear idea of where and how the body is moving
- B. Relation to flight
 - i. Flying can result in conflicting information being sent to the brain, leading to disorientation
 - ii. Visual System (eyes)
 - a. Flight in VMC
 - The eyes are the major orientation system and usually prevail over false sensations from the other systems when outside references are available
 - b. Flight in IMC
 - When visual cues are taken away, the eyes cannot correct for the false sensations, and a pilot can become disoriented
 - iii. Vestibular System (ears)
 - a. The vestibular system in the inner ear allows the pilot to sense movement and determine orientation in the surrounding environment
 - b. Two major parts: Semicircular Canals and Otolith Organs
 - c. Semicircular Canals
 - Explanation
 - a. Detect angular acceleration
 - b. Three tubes at right angles to each other
 - 1. One on each of the three axes; pitch, roll, and yaw

- c Each canal is filled with a fluid, called Endolymph Fluid
- d In the center of the canal is the cupola, a gelatinous structure that rests upon sensory hairs located at the end of the vestibular nerves

- How they work: In a Turn

- a When the ear canal is moved in its plane (a turn is started), the relative motion of the fluid moves the cupola, which stimulates the sensory hairs to provide the sensation of turning

1. Glass of water illustration: wall is moving but water is not

- b The ear only detects turns of a short duration

1. After approximately 20 sec, the fluid accelerates and moves at the same speed as the ear canal
2. At the same speed, the hairs detect no relative movement and the sensation of turning ceases (it feels like straight and level flight)

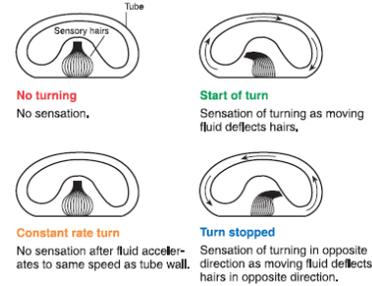
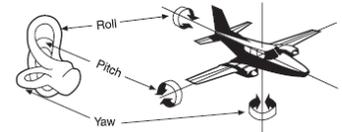
- a. Glass of water illustration: water matches the speed of the glass

3. When the turning stops, the ear canal stops moving but the fluid does not

- a. This moves the sensory hairs in the opposite direction, creating the sensation of a turn in the opposite direction even though the aircraft is flying straight

- c This can be demonstrated: Establish a 30° bank turn, tell the student to close their eyes and let you know when the aircraft is flying straight. Maintain the turn, after about 20 seconds the student should feel as though the aircraft is out of the turn, have them open their eyes. Try it again, but this time once they believe the aircraft is straight, roll out of the bank. The student will feel like the aircraft is turning in the opposite direction.

The semicircular tubes are arranged at approximately right angles to each other, in the roll, pitch, and yaw axes.



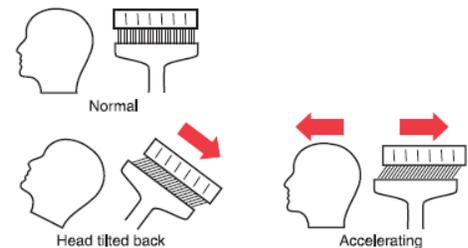
- d. Otolith Organs

- Explanation

- a Detect linear acceleration/gravity
- b A gelatinous membrane containing chalk like crystals covers the sensory hairs
- c When you tilt your head, the weight of the crystals cause the membrane to shift due to gravity and the sensory hairs detect the shift

- Acceleration

- a Forward acceleration gives the illusion of the head tilting backward and deceleration gives the illusion of the head tilting forward



- iv. Postural System (nerves)

- a. Nerves in the body's skin, muscles, and joints constantly send signals to the brain, which signals the body's relation to gravity
- b. Acceleration will be felt as the pilot is pushed back into the seat
- c. False Sensations
 - Forces created in turns can lead to false sensations of the direction of gravity, and may give the pilot a false sense of which way is up
 - a The brain has no way of differentiating between the forces of a turn (coordinated or uncoordinated) and the force of gravity
 - Turbulence can create motions that confuse the brain

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- Fatigue or illness can exacerbate these sensations
- C. Countering the sensations
- Recognize the problem, disregard the false sensations, and rely totally on the flight instruments
 - The pilot must have an understanding of the problem and the self-confidence to control the aircraft using only instrument indications (do not trust the feelings, trust the instruments)
- 6. Motion Sickness**
- A. Cause
- i. Caused by the brain receiving conflicting messages about the state of the body
 - ii. Anxiety and stress also affect motion sickness
- B. Symptoms
- i. General discomfort
 - ii. Nausea
 - iii. Dizziness
 - iv. Paleness
 - v. Sweating
 - vi. Vomiting
- C. Treatment
- i. Open fresh air vents
 - ii. Focus on objects outside the airplane
 - iii. Avoid unnecessary head movement
 - iv. Take control of the aircraft and fly smooth, straight and level
 - a. Letting someone else fly can make the situation worse
 - v. Generally goes away after a few flight lessons
 - a. After more used to flying and stress/anxiety are reduced
- 7. Carbon Monoxide Poisoning**
- A. How it Happens – In the Plane
- i. Carbon Monoxide (CO) is a colorless, odorless gas produced by all internal combustion engines
 - ii. Aircraft heater vents and defrost vents provide CO a passageway into the cabin if the engine exhaust system has a leak or is damaged
- B. How it Happens – In the Body
- i. CO attaches itself to the hemoglobin in the blood
 - a. It does this about 200 times easier than oxygen
 - b. CO prevents the hemoglobin from carrying oxygen to the cells resulting in Hypemic Hypoxia
 - ii. It can take up to 48 hours for the body to dispose of CO
 - iii. If the poison is severe enough it can result in death
- C. Effects of CO
- i. Headache
 - ii. Blurred vision
 - iii. Dizziness
 - iv. Drowsiness
 - v. Loss of muscle power
- D. Detecting and Correction
- i. If a strong odor of exhaust gases is detected, assume CO is present
 - a. CO may be present in dangerous amounts even if no exhaust odor is detected
 - ii. If exhaust odor is noticed or symptoms are experienced immediate actions should be taken
 - a. Turn off the heater
 - b. Open fresh air vents and windows

- c. Use supplemental oxygen, if available
- d. Land

8. Fatigue and Stress

A. Fatigue

i. Effects

- a. Degradation of attention and concentration
- b. Impaired coordination
- c. Decreased ability to communicate

ii. Causes

- a. Sleep loss
- b. Exercise
- c. Physical work
- d. Stress and prolonged performance of cognitive work can result in mental fatigue

iii. Categories

a. Acute Fatigue (short term)

- Definition
 - a Tiredness felt after a period of strenuous effort, excitement, or lack of sleep
 - b Normal occurrence in everyday life
- Skill Fatigue – A special type of acute fatigue affecting a person’s piloting skill
 - a Effects on performance
 - 1. Timing Disruption
 - a. Appearing to perform a task as usual, but the timing of each component is slightly off
 - b. Performance is less smooth as each component is performed as a separate part instead of part of an single, integrated activity
 - 2. Disruption of the perceptual field
 - a. Concentrating attention upon movements or objects in the center of vision and neglecting those in the periphery
 - b. May be accompanied by a loss of accuracy/smoothness in control movements
- Causes
 - a Mild hypoxia
 - b Physical stress
 - c Psychological stress
 - d Depletion of physical energy resulting from psychological stress
- Prevention
 - a Proper diet
 - 1. Prevents the body from having to consume its own tissues as an energy source
 - b Adequate rest and sleep
 - 1. Maintains the body’s store of vital energy
 - 2. The difference between flying fatigued and rested can be night and day, get enough sleep!

b. Chronic Fatigue

- Definition
 - a Fatigue extending over a long period of time
 - b Usually has psychological roots, an underlying disease is sometimes responsible
- Symptoms
 - a Weakness

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- b Tiredness
- c Palpitations of the heart
- d Breathlessness
- e Headaches
- f Irritability
- g Stomach or intestinal problems (More rare)
- h Generalized aches and pains throughout the body
- i Emotional Illness (when conditions become serious enough)

- Prevention
 - a Usually requires treatment by a physician

iv. Prevention

- a. If suffering from acute fatigue, stay on the ground
- b. Fatigue in the cockpit cannot be overcome through training or experience
- c. Getting adequate rest is the only way to prevent fatigue
 - Avoid flying without:
 - a A full night's rest
 - b After working excessive hours
 - c After an especially exhausting or stressful day
- d. Suspected chronic fatigue should be treated by a physician

B. Stress

i. The body's response to physical and psychological demands placed upon it

ii. Body's Reaction

- a. Releasing chemical hormones (such as adrenaline) into the blood
- b. Increasing metabolism to provide more energy to the muscles
- c. Blood sugar, heart rate, respiration, blood pressure, and perspiration all increase

iii. Stressors

- a. Physical stress (noise or vibration)
- b. Physiological stress (fatigue)
- c. Psychological stress (difficult work or personal situations)

iv. Categories of Stress

- a. Acute Stress (short term)
 - Involves an immediate threat that is perceived as danger
 - The type of stress that triggers a "fight or flight" response in an individual
 - Normally, a healthy person can cope with acute stress and prevent stress overload
 - On-going acute stress can develop into chronic stress

v. Chronic Stress (long term)

- a. A level of stress that presents an intolerable burden, exceeds the ability of an individual to cope, and causes individual performance to fall sharply
- b. Causes
 - Unrelenting psychological pressures such as loneliness, financial worries and relationship or work problems
- c. Pilots experiencing this level of stress are not safe and should not fly

9. Dehydration

A. Definition

i. Critical loss of water from the body

B. Effects

i. First noticeable effect is fatigue

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- a. Top physical and mental performance is difficult, if not impossible
- C. How it affects flying
 - i. Flying for long periods of time in hot temperatures or at high altitudes increases the susceptibility of dehydration since the dry air at altitude increases the rate of water loss from the body
 - ii. If the fluid is not replaced, fatigue progresses to dizziness, weakness, nausea, tingling of the hands and feet, abdominal cramps, and extreme thirst
 - iii. Attention is taken from flying and skills diminish
- D. Prevention
 - i. Carry an ample supply of water on any flight
 - ii. If the airplane has a canopy or roof window, wearing light colored, porous clothing and a hat will provide protection
 - iii. Keep the cockpit well ventilated

10. Alcohol and Other Drugs

- A. DON'T drink and fly
 - i. A hangover can impair anyone attempting to fly
 - ii. More susceptible to disorientation and hypoxia
 - iii. FARS – 8 hrs 'from bottle to throttle' (8 hrs. and not feeling the effects of alcohol is better)
- B. Medications
 - i. Can affect pilot performance
 - a. Side effects of medicines impair judgment, coordination, vision
 - ii. Anything that depresses nervous system can make a pilot more susceptible to hypoxia
 - iii. Do not fly while taking any medication, unless approved by the FAA

11. Nitrogen and Scuba Diving

- A. Provide the body with enough time to rid itself of excess nitrogen absorbed from diving
 - i. Decompression sickness can occur and create an in-flight emergency
 - a. Nitrogen bubbles can form in the bloodstream, spinal cord or brain as pressure decreases with altitude
 - In extreme cases this can result in death, in less severe cases this can result in impairment or severe pain
 - b. Wait at least 12 hrs after a dive not requiring a controlled ascent before flight up to 8,000'
 - For flights above 8,000' wait at least 24 hrs.
 - c. Wait at least 24 hrs after a dive which required a controlled ascent
 - ii. If a decompression is experienced (especially a rapid decompression) symptoms can be brought on quickly

12. IM SAFE

- A. Your own preflight
 - i. Illness
 - ii. Medical
 - iii. Stress
 - iv. Alcohol
 - v. Fatigue
 - vi. Emotion

Conclusion:

Brief review of the main points

There are many factors a pilot needs to be aware of in order to ensure a safe flight and to understand the medical risks involved in flying.

PTS Requirements:

To determine that the applicant exhibits knowledge of the elements related to aeromedical factors by explaining:

1. How to obtain an appropriate medical certificate.
2. How to obtain a medical certificate in the event of a possible medical deficiency.
3. The causes, symptoms, effects, and corrective action of the following medical factors:
 - a. hypoxia.
 - b. hyperventilation.
 - c. middle ear and sinus problems.
 - d. spatial disorientation.
 - e. motion sickness.
 - f. carbon monoxide poisoning.
 - g. fatigue and stress.
 - h. dehydration.
4. The effects of alcohol and drugs, and their relationship to flight safety.
5. The effect of nitrogen excesses during scuba dives and how this affects pilots and passengers during flight.