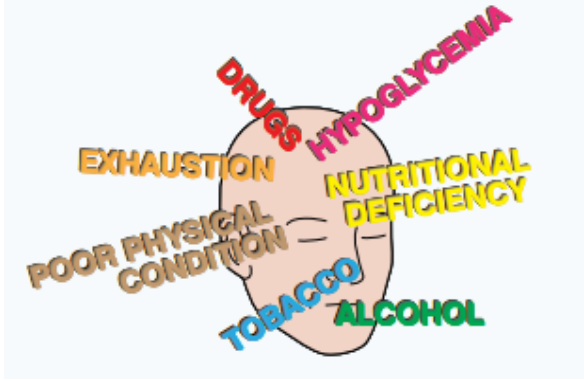


Human Factors

Objective	
<p>To ensure the applicant learns and can exhibit a clear understanding of the human factors affecting pilots and passengers during flight.</p>	
Purpose <p>Flying demands very high levels of human performance, but pilots, just like anyone else, are subject to factors that impede their performance. This lesson introduces pilots to the medical certification process, the human (physiological, psychological, and cognitive) factors that affect pilots and their passengers in flight, as well as their causes, symptoms, and treatments.</p>	
Schedule	Equipment
<ul style="list-style-type: none"> • Ground Lesson: 20 minutes • Student Q&A: 10 minutes 	<ul style="list-style-type: none"> • Whiteboard / Markers (optional)
Student Actions	Instructor Actions
<ul style="list-style-type: none"> • Ask any questions, receive study material for the next lesson. • Review listed references. 	<ul style="list-style-type: none"> • Deliver the ground lesson (below). • Answer student questions.
Completion Standards	
<ul style="list-style-type: none"> • Student can explain the following concepts: <ul style="list-style-type: none"> • How to obtain a medical certificate, SODA, Special Issuance • Common aeromedical factors, their causes, symptoms, and treatments, including <ul style="list-style-type: none"> ○ Hypoxia ○ Hyperventilation ○ Middle Ear or Sinus Problems ○ Spatial Disorientation ○ Motion Sickness ○ CO Poisoning ○ Fatigue, Stress, Dehydration ○ Excess Nitrogen (Decompression Sickness) • Common cognitive and psychological concepts, including <ul style="list-style-type: none"> ○ ADM/SRM, Task Prioritization, Dealing with Distractions, and the PAVE/IMSAFE Checklist ○ Confirmation and Expectation Bias ○ The Five Hazardous Attitudes • The rules and regulations concerning alcohol and drugs, and their impact on flight safety 	

References

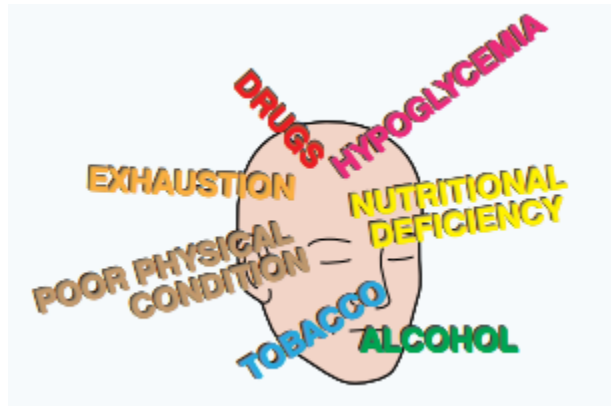
- FAA-H-8083-25B (Pilot's Handbook of Aeronautical Knowledge) - Chapter 17 [Aeromedical Factors]
- FAA-S-ACS-6C (Private Pilot ACS) and FAA-S-ACS-7B (Commercial Pilot ACS) - Area I Task H
- FAA-S-ACS-8B w/ Change 1 (Instrument Airplane ACS) - Area I Task A
- FAA-S-ACS-25 (CFI ACS) - Area II Task A and FAA-S-8081-9D (CFII PTS) - Area II Task B

Ground Lesson Outline

- Obtaining a Medical Certificate
 - Possible Complications, Disqualifying Conditions, Special Issuance, SODA
- Common Aeromedical Factors - Pilots should consider PAVE/IMSAFE before every flight!
 - Hypoxia - Inadequate oxygen supply, particularly to the brain (FAA Oxygen Requirements § 91.211)
 - Types - Hypoxic (not enough oxygen in the air), Hypemic (blood can't carry, e.g. CO poisoning), Stagnant (blood not flowing, high G's), Histoxic (cells can't use, e.g. alcohol and drugs)
 - Cause - Flight at high altitude (esp. Above 10,000), Anemia, Alcohol/Drugs, etc.
 - Symptoms - Euphoria, carefree feeling, blue fingernails, headache, drowsiness, etc.
 - Effects - Reduced mental function, somewhat like drunkenness.
 - Treatment - Descend or increase oxygen supply!
 - Hyperventilation - Excessive rate of breathing, common in high altitude or high stress situations.
 - Cause - Stress, high breathing rate on pure oxygen supply, etc. Insufficient CO₂.
 - Symptoms/Effects - Similar to Hypoxia (also tingling, dizzy), can lead to loss of consciousness.
 - Treatment - Must reduce breathing rate or oxygen flow.
 - Middle Ear and Sinus Problems - Caused by blockages in sinuses or middle ear, can be extremely painful, especially during climbs and descents. Oral decongestants create side effects, do not use!
 - Cause, Symptoms, Effects - Usually cold or sinus infection, pain or partial hearing loss.
 - Descend slowly, try to equalize the ears gently. Avoid flying when sick!
 - Spatial Disorientation - Caused by unreliability of vestibular system, especially when visual cues are lost! Brain uses vestibular, somatosensory, and visual system together to maintain orientation.
 - Spatial Illusions - The Leans, Coriolis, Graveyard Spiral, Somatogravic, Inversion, Elevator
 - Visual Illusions - False Horizon, Autokinesis, Runway Width, Terrain Slope, Featureless Terrain
 - Motion Sickness - Brain receiving conflicting information about the body. Can be exacerbated by stress.
 - Avoid turbulence, keep short lessons, get fresh air, etc. Can be overcome with time.
 - Carbon Monoxide Poisoning - Often caused by exhaust leaks, etc. Causes Hypemic Hypoxia.
 - Smokers also experience some effects.
 - Fatigue and Stress - Increased demands on the body. Causes other health problems, poor pilot perf.
 - Acute vs Chronic
 - Dehydration - Critical lack of water in the body. Often caused by hot, unventilated cockpits, etc.
 - Symptoms include headache, fatigue, cramps, sleepiness, and dizziness. Drink more water!
 - Excess Nitrogen Saturation / Scuba Divers - Caused by increased partial pressure of nitrogen in compressed air. Can be dangerous or even fatal! Must allow time to decompress (12-24 hours)
- Drugs and Alcohol - § 91.17 - Avoid alcohol, but even prescription drugs can cause dangerous impairment!
 - Rules and Regulations
 - Cannot act as a crewmember - Within 8 hours of drinking, BAC >0.04, Under the Influence
 - Cannot allow anyone who appears intoxicated onboard.
 - Relationship to Flight Safety - Flying under the influence is never safe and create disastrous results!
- Cognitive and Psychological Factors
 - ADM / SRM - Task Prioritization, PAVE/IMSAFE
 - Distractions, Loss of Situational Awareness, Disorientation, Confirmation and Expectation Bias
 - The Five Hazardous Attitudes - Anti-Authority, Impulsivity, Invulnerability, Resignation, Macho

Ground Lesson Content

- **Obtaining a Medical Certificate** - FAA Airman Medical Certificates are granted by Aviation Medical Examiners (AMEs), who are FAA-designated doctors who represent the FAA for the purposes of medical certification.
 - **Search for an AME** - <https://www.faa.gov/pilots/amelocator/>
 - **Apply at MedXPress** - <https://medxpress.faa.gov/medxpress/>
 - **Possible Complications**
 - **Disqualifying Conditions**
 - Angina Pectoris
 - Bipolar Disorder
 - Cardiac Valve Replacement
 - Coronary Heart Disease that has been treated or, if untreated, that has been symptomatic or clinically significant
 - Diabetes Mellitus requiring hypoglycemic medication
 - Disturbance of Consciousness without satisfactory explanation of cause
 - Epilepsy
 - Heart Replacement (Cardiac Transplant)
 - Myocardial Infarction
 - Permanent cardiac pacemaker
 - Personality Disorder that is severe enough to have repeatedly manifested itself by overt acts
 - Psychosis
 - Substance Abuse
 - Substance Dependence
 - Transient Loss of Control of Nervous System function(s) without satisfactory explanation of cause
 - **Special Issuance** - § 67.401(a) - At discretion of the Federal Air Surgeon, may expire. Used in situations where, for example, the applicant has a disqualifying condition but it has been treated in a manner acceptable to the FAA and does not present a safety of flight issue. Usually requires treatment by FAA-designated specialists, and working with one or more Aviation Medical Examiners.
 - **Statement of Demonstrated Ability (SODA)** - § 67.401(b) - At discretion of the Federal Air Surgeon, does not expire if condition unchanged. Commonly used in cases of a medical disability, where it does not affect safety of flight. For example: A pilot with one leg. Requires 'proving' to FAA representatives that the condition is not a serious impediment.
- **Common Aeromedical Factors** - There are many common aeromedical factors that affect pilots. Flying is a challenging environment for the human body. Pilots should consider doing the PAVE/IMSAFE checklist (described below) to evaluate their general physiological condition before every flight to ensure they are medically fit. However, even physiologically fit pilots are susceptible to some common aeromedical factors in flight:

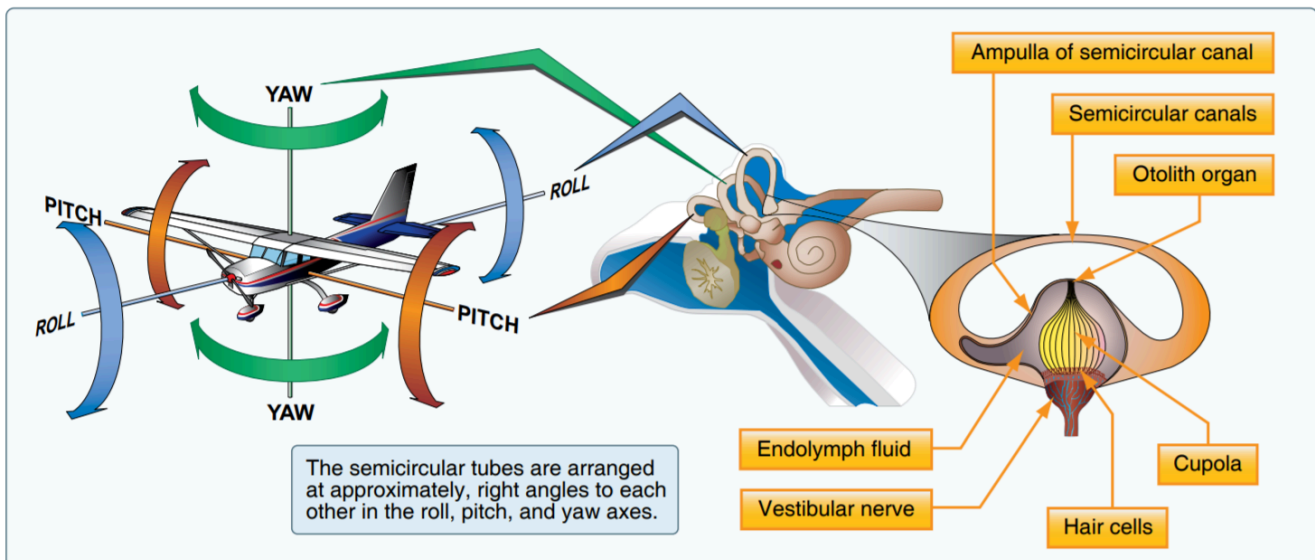


- **Hypoxia** - Inadequate oxygen supply, particularly to the brain
 - **Types**
 - **Hypoxic** - Not enough oxygen in the air, e.g. high altitude, suffocation
 - How to Deal With
 - High performance planes pressurize the cabin
 - GA aircraft generally use 100% oxygen
 - The FAA requires (§ 91.211)
 - When between 12500ft and 14000ft for more than 30 minutes that all crew members must be on oxygen
 - Above 14000ft, all crew members must be on oxygen full time
 - Above 15000ft all passengers must be offered oxygen
 - The FAA recommends
 - Using oxygen at night above 5000ft
 - Using oxygen during the day above 10000ft
 - **Hypemic** - Blood can't carry sufficient oxygen, e.g. CO poisoning
 - **Stagnant** - Blood not flowing, e.g. high G's or poor blood circulation
 - **Histoxic** - Cells can't use oxygen, e.g. alcohol and drugs
 - **Cause** - Flight at high altitude (esp. Above 10,000), Anemia, Alcohol/Drugs, etc.
 - **Symptoms** - Euphoria, carefree feeling, blue fingernails, headache, drowsiness, etc.
 - **Effects** - Reduced mental function, somewhat like drunkenness.
 - **Treatment** - Descend or increase oxygen supply! Can happen very fast at high altitudes!

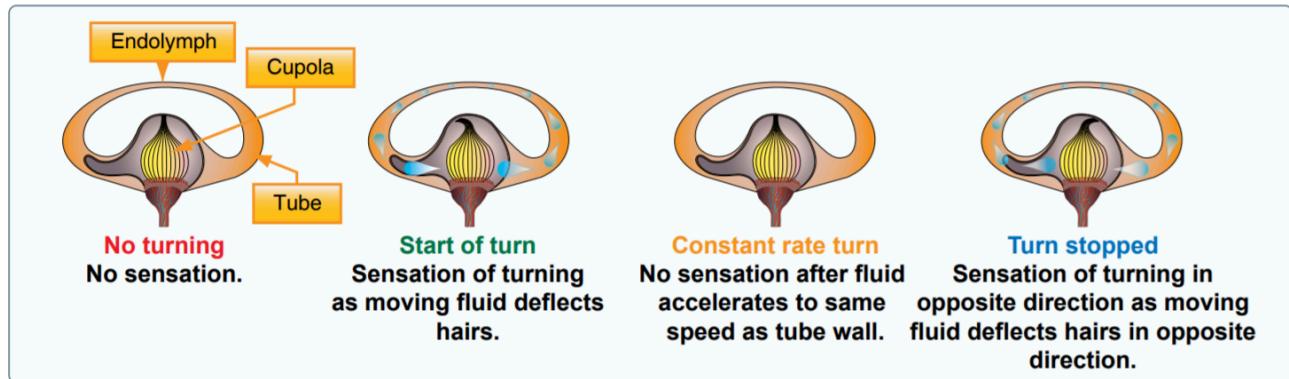
Altitude	Time of useful consciousness
45,000 feet MSL	9 to 15 seconds
40,000 feet MSL	15 to 20 seconds
35,000 feet MSL	30 to 60 seconds
30,000 feet MSL	1 to 2 minutes
28,000 feet MSL	2½ to 3 minutes
25,000 feet MSL	3 to 5 minutes
22,000 feet MSL	5 to 10 minutes
20,000 feet MSL	30 minutes or more

- **Hyperventilation** - Excessive rate of breathing, common in high altitude or high stress situations. Results in a CO₂ deficiency.
 - **Cause** - Stress, high breathing rate on pure oxygen supply, etc. Insufficient CO₂.
 - **Symptoms/Effects** - Similar to Hypoxia, can lead to loss of consciousness. Also:
 - Dizziness/Lightheadedness
 - Tingling sensation

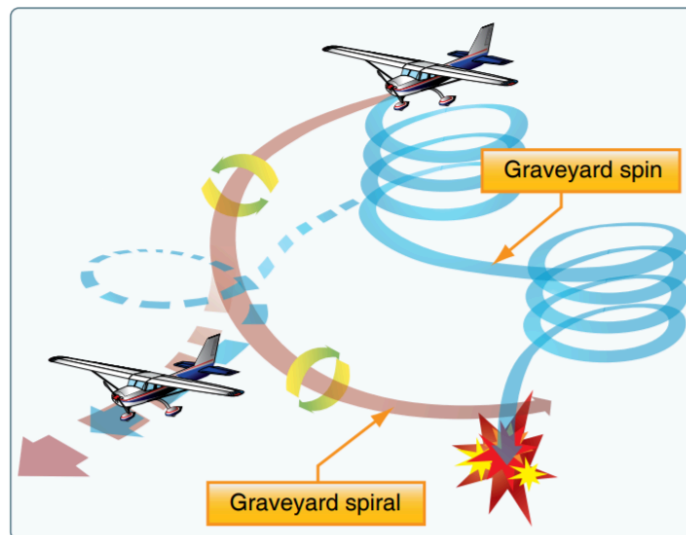
- Visual Impairment
- Muscle Spasms
- Hot and Cold Feelings
- **Treatment** - Must reduce breathing rate or oxygen flow.
- **Middle Ear and Sinus Problems** - Caused by blockages in sinuses or middle ear, can be extremely painful, especially during climbs and descents. Oral decongestants can create side effects that are harmful to pilot performance, do not use when flying!
 - **Cause, Symptoms, Effects** - Usually cold or sinus infection, pain or partial hearing loss.
 - **Treatment** - Descend slowly, try to equalize the ears gently. Avoid flying when sick, or with sick passengers! Can try holding your nose and blowing gently.
- **Spatial Disorientation** - Caused by unreliability of vestibular system, especially when visual cues are lost!
 - **3 Systems** - The brain uses input from 3 separate systems to maintain a mental model of orientation:
 - Vestibular - Based on sensitive, fluid-filled canals in the inner ear. Senses accelerations.
 - Somatosensory - Senses accelerations using nerves on skin, joints, etc. (e.g. G-Forces)
 - Visual System - Orientation is derived from the visual scene.
 - **Spatial Illusions** - In the absence of *reliable* visual information, the brain can use only the vestibular and somatosensory systems. These systems are unreliable in the absence of visual system input (which serves as a constant correction). This causes the brain to become confused about the orientation. Because these systems primarily depend on accelerations in the various axes, they are susceptible to confusion during long, gentle, sustained maneuvers, such as constant-rate turns.



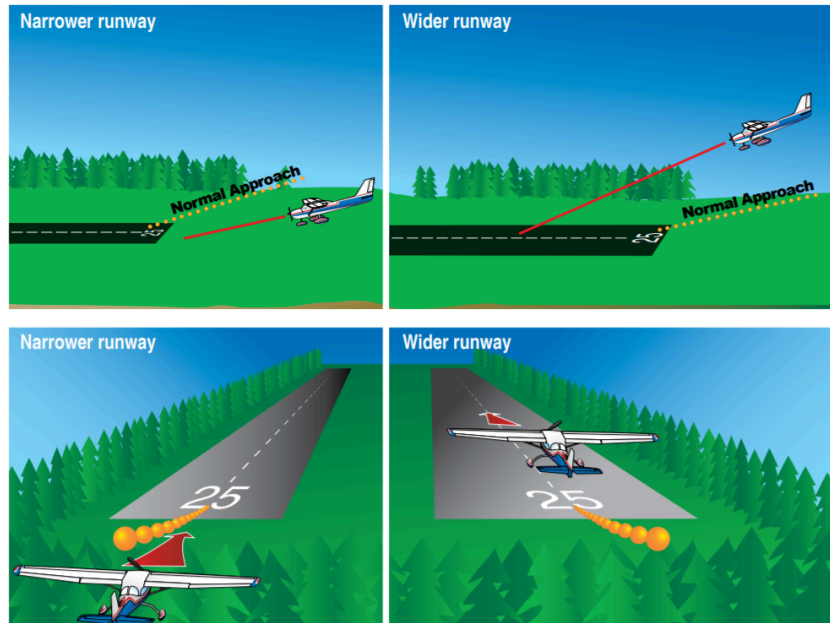
- **The Leans** - During a rollout from a prolonged, constant-rate turn, the pilot feels as if they're leaning to one side when straight and level.



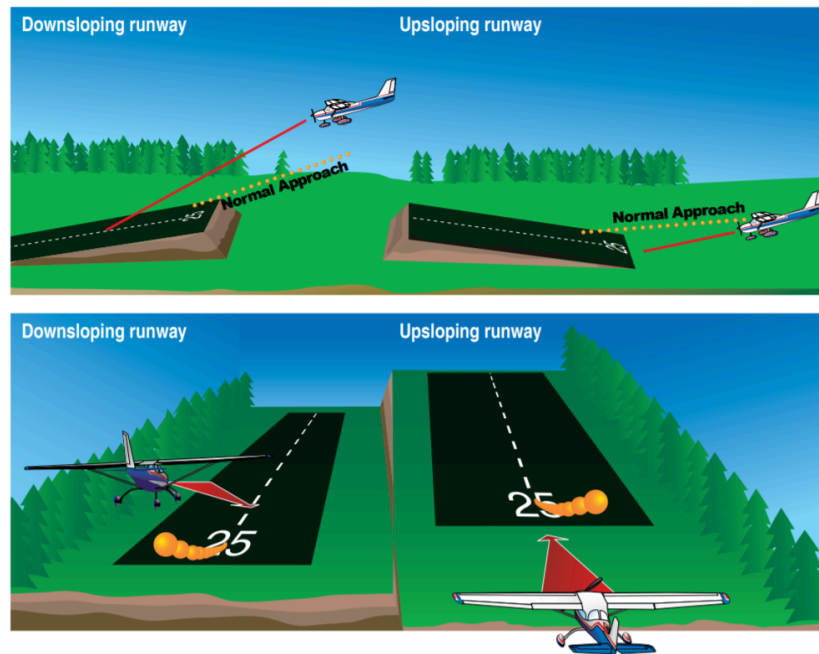
- **Coriolis Illusion** - During a prolonged, constant-rate turn, movement of the head causes pilots to feel (fake) rotation in a different axis.
- **Graveyard Spiral** - Similar to the leans, where the pilot continuously inputs the wrong corrective control inputs, leading to a tightening, descending spiral.



- **Somatogravic Illusion** - Accelerations can cause the feeling of pitching up, and decelerations feel like pitching down.
- **Inversion Illusion** - Abruptly leveling off from a climb can cause a feeling of tumbling backwards.
- **Elevator Illusion** - Abrupt, brief, vertical accelerations can create a sense of climbing or descending, even when level.
- **Visual and Optical Illusions** - The visual system is also susceptible to certain kinds of visual illusions, which can be worsened by poor visibility, haze, fog, etc.
 - **False Horizon** - A sloping cloud layer, obscured sky, ground lighting, or stars, can all contribute to incorrectly perceiving a false horizon.
 - **Autokinesis** - Focusing on a small point light in a dark area for a long time can cause an appearance of the light moving, even when it is not.
 - **Runway Width** - A narrower than usual runway can cause the appearance of being above glideslope, causing the pilot to fly excessively low on approach.



- **Terrain/Runway Slope** - An upsloping runway creates the illusion of being higher than normal, and vice-versa.



- **Featureless Terrain Illusion** - Flight over featureless terrain (such as still water, smooth snow, etc) creates an illusion of being higher than the actual altitude.
- **Motion Sickness** - Brain receiving conflicting information about the orientation of the body. Can be exacerbated by stress or anxiety.
 - Potentially affects everyone from time to time.
 - Avoid turbulence, keep short lessons, get fresh air, etc.
 - Can be overcome with time.
- **Carbon Monoxide Poisoning** - Often caused by exhaust leaks, etc.
 - Causes Hypemic Hypoxia, and potentially leads to confusion or loss of consciousness.
 - Extremely dangerous and must be avoided. **If suspected, open windows or vents to**

get fresh air.

- CO Detectors are installed in some aircraft. CO is odorless and colorless, so very difficult to detect! **Monitor it periodically during flight!**



- Smokers also experience some effects. (Smoking can create the effect of being at 8,000 feet)
- **Fatigue and Stress** - Increased demands on the body. Causes other health problems, poor pilot performance.
 - **Acute Stress** - Short-term stress, e.g. “fight or flight”. Physical (heat, pressure, etc.), physiological (thirst, illness, etc.), psychological (anxiety, etc.) in cause. Cured by alleviating the underlying cause.
 - **Acute Fatigue** - Tiredness after a period of short term physical or mental exertion, etc. Normally cured by rest.
 - **Chronic Fatigue** - Reduces ability to fly safely. Caused by insufficient recovery time from periods of acute fatigue.
 - Airlines Pilots - Require 10 hours of rest (8 hours for sleep) and max of 30 hours per week (8 hours per day without a rest period)
 - Airlines also conduct fatigue education and awareness training for flight crew and dispatchers.
 - Reduced speed and accuracy of performance, lapses of attention, delayed reactions, impaired reasoning and decision-making, poor risk evaluation, reduced situational awareness, low motivation to perform optional activities.
 - **Heavy fatigue is more debilitating than 3 alcoholic drinks**
 - **To Reduce Fatigue**
 - Get plenty of sleep, exercise, drink water (coffee, soda is only temporary), shift position in seat or walk around if able, nap in crew rest if possible
 - **Chronic Stress** - Relationship, school/work problems, etc
 - **Causes performance issues, pilot should ground themselves till it is dealt with.**
- **Dehydration** - Critical lack of water in the body. Often caused by hot, unventilated cockpits, etc.
 - Symptoms include headache, fatigue, cramps, sleepiness, and dizziness.
 - Drink more water!
- **Excess Nitrogen Saturation / Scuba Divers** - Caused by increased partial pressure of nitrogen in compressed air. Breathing compressed air during dives causes the blood and body to absorb higher than normal amounts of nitrogen. When in an unpressurized airplane, or even a pressurized airplane cabin, the lower pressure causes the nitrogen to form bubbles and try to escape from bodily fluids.
 - **This can be dangerous or even fatal to anybody affected!**
 - Must allow time to decompress (12-24 hours) depending on the depth of the dive, and whether it required decompression stops!

- **Drugs and Alcohol - § 91.17**
 - **Rules and Regulations**
 - Cannot act as a crewmember when
 - Within 8 hours of drinking
 - BAC >0.04
 - While under the Influence
 - Cannot allow anyone who appears intoxicated onboard
 - **Relationship to Flight Safety** - Flying under the influence is never safe and create disastrous results!
- **Cognitive and Psychological Factors** - Aside from physiological factors, cognitive and psychological factors also greatly affect the outcome of any flight. Distractions, biases, and hazardous attitudes can all add risk to any flight.
 - **Aeronautical Decision Making (ADM) and Single Pilot Resource Management (SRM)** helps pilots maintain a margin of safety by giving a structured framework to make decisions, and avoiding unnecessary risk.
 - **Task Prioritization** - Especially in the case of SRM, it is vital that pilots divide their attention appropriately, meaning that urgent items are paid more attention. The old adage of “*Aviate, Navigate, Communicate*” is a great basis for making such prioritization decisions.
 - When dealing with complex avionics, there is additionally a higher susceptibility to distraction... getting lost in menus and buttonology is a serious problem. Always divide attention when performing these tasks!
 - **D-E-C-I-D-E Model** - Simple and logical decision making process
 - **Detect** - See a problem
 - **Estimate** - Determine whether action needs to be taken
 - **Choose** - Choose a course of action
 - **Identify** - Identify steps to achieve course of action
 - **Do** - Implement the steps
 - **Evaluate** - Evaluate the performance
 - **PAVE** - Divides risks into categories
 - **Pilot** - Risk factors affecting pilot performance, health (IMSAFE), etc.
 - **Aircraft** - Risk factors affecting the airplane, maintenance, etc.
 - **enVironment** - Risk factors relating to weather, unfamiliar airports, etc.
 - **External Pressures** - Risk factors relating to external pressures, e.g. get-there-itis
 - **CARE** - Determine level of Risk
 - **Consequences** - What would happen?
 - **Alternatives** - What else could we do?
 - **Reality** - Be open to recognizing when things are going wrong
 - **External Pressures** - Factors which may influence our risk taking decisions
 - **TEAM** - Dealing with Risks
 - **Transfer** - Ask someone else? Get help
 - **Eliminate** - Can we eliminate the risk somehow?
 - **Accept** - Can we just accept the risk? Is it worth it?
 - **Mitigate** - Can we do something to minimize the consequences or likelihood of occurrence?
 - **Distractions, Loss of Situational Awareness, and Disorientation** - All pilots are susceptible to these issues. A misbehaving system captures your attention, a non-sterile cockpit causes a turn or radio call to be missed, and confusion can follow, leading to disorientation. Pilots must remain vigilant during flight and observe sterile cockpit rules when appropriate. It is crucial to

- **Impulsivity** - “Do it quickly”
- **Invulnerability** - “It won’t happen to me”
- **Resignation** - “What’s the use?”
- **Macho** - “I can do it”
- **Antidotes To Hazardous Attitudes**
 - **Anti-Authority** - Follow the rules, they are there for a reason.
 - **Impulsivity** - Not so fast, think.
 - **Invulnerability** - It can happen to you.
 - **Resignation** - I am not helpless, I can make a difference.
 - **Macho** - Taking chances is foolish.