II.A. Aeromedical Factors

Objectives	The student should exhibit knowledge regarding aeromedical factors as required in the PTS.
Key Elements	✈ IMSAFE self-checklist ✈ Trust the instruments ✈ CO is 200 times more likely to bond with blood than oxygen ✈ Drugs + alcohol + flying = very bad
Elements	✈ Obtaining an appropriate medical certificate ✈ Hypoxia ✈ Hyperventilation ✈ Spatial disorientation ✈ Motion sickness ✈ CO poisoning ✈ Fatigue and stress ✈ Dehydration ✈ Drugs and alcohol ✈ Scuba diving and nitrogen ✈ IMSAGE
Schedule	1. Discuss objectives 2. Review material 3. Development 4. Conclusion
Equipment	✈ White board ✈ Markers ✈ References
Instructor's Actions	1. Discuss lesson objectives 2. Present lecture 3. Questions 4. Homework
Student's Actions	Participate in discussion Take notes
Completion Standards	The student has the ability to explain different aeromedical factors and their importance to flying and possible effects during flight.

References	FAA-H-8083-25B, *Pilot's Handbook of Aeronautical Knowledge* (Chapter 17) AIM, *Aeronautical Information Manual* (Chapter 8) 14 CFR 61.24

Instructor Notes

Introduction	Overview—review objectives and key ideas. 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.
Obtaining an appropriate medical certificate	Issued after a routine medical examination. Administered by FAA-designated doctors—Aviation Medical Examiners (AME) FAA directory of AMEs: FSDO, FSS, FAA office Medical certificates can be issued even with possible medical deficiencies, but operating limitations may be imposed. Obtain assistance from an AME and the local FSDO. Once a medical is obtained, you have to self-regulate using your judgment.
Hypoxia	Means reduced oxygen, not enough oxygen. Brain is particularly vulnerable to oxygen deprivation. Can be caused by several factors—an insufficient supply of oxygen, inadequate transportation of oxygen, the inability of the body tissues to use oxygen.
Hypoxic hypoxia	Result of insufficient oxygen available to the lungs, because of blocked airways or drowning depriving lungs of oxygen. For pilots, reduction in partial pressure of oxygen at high altitude does this. Percentage of oxygen in atmosphere is constant, but its partial pressure decreases proportionally as atmospheric pressure decreases. Airplane ascending—percentage of each gas remains the same, but there are fewer molecules available at the pressure required for them to pass between the membranes in the respiratory system. Hypoxic hypoxia—decrease of oxygen molecules at sufficient pressure.
Hypemic hypoxia	Occurs when the blood is not able to take up and transport a sufficient amount of oxygen to the cells in the body. Result of oxygen deficiency in the blood. Possible causes: insufficient blood volume due to severe bleeding or blood donation, certain blood diseases (anemia), hemoglobin that is chemically unable to bind oxygen molecules, CO poisoning. Slight effects of blood loss at ground effect but risks when flying.
Stagnant hypoxia	Oxygen-rich blood in lungs not moving to tissues that need it. Can result from shock, the heart failing to pump blood effectively, a constricted artery.

During flight, can occur when pulling excessive positive G's. Cold temperatures can also reduce circumstances and decrease the blood supplied to extremities.

Histotoxic hypoxia

Inability of cells to effectively use oxygen—oxygen is being transported to cells that need it, but they are unable to make use of it.
Causes: alcohol and other drugs, narcotics, poison. Drinking one ounce of alcohol can educate to about an additional 2,000 ft of physiological altitude.

Hypoxia symptoms

Euphoria, carefree feeling at first. Extremities become less responsive and flying becomes less coordinated with increased oxygen starvation. Field of vision begins to narrow, instrument interpretation becomes difficult. Cyanosis, headache, increased reaction time, impaired judgment, euphoria, visual impairment, drowsiness, lightheaded/dizzy sensation, tingling in fingers or toes, numbness.

Useful consciousness

The maximum time the pilot has to make rational, life saving decisions, and carry them out at a given altitude without supplemental oxygen.

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

Treatment

Flying at lower altitudes (emergency descent) or using supplemental oxygen.

Hyperventilation

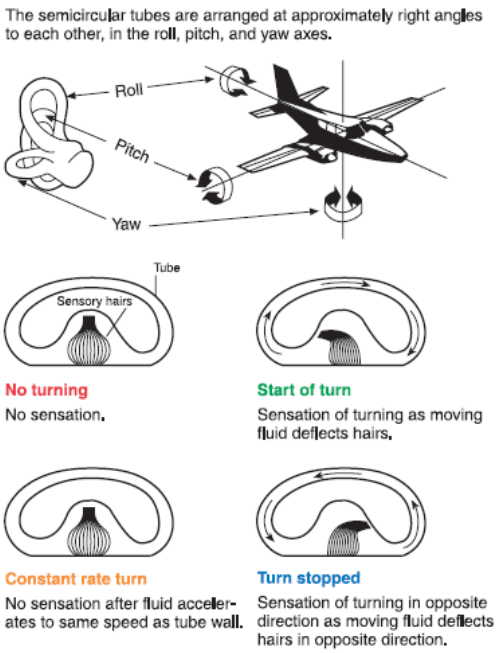
Occurs when experiencing emotional stress, fright, or pain. The breathing rate and depth increase, although the CO2 level in the blood is at a reduced level.
Excessive loss of CO2 from body can lead to unconsciousness due to the respiratory system's overriding mechanism to reduce the breathing rate. Pilots may unconsciously increasing their breathing rate.

	If flying at higher altitudes, pilots tend to breathe more rapidly than normal, often leading to hyperventilation.
Symptoms	Similar to hypoxia symptoms—important to diagnose correctly to treat proper condition. Headache, decreased reaction time, impaired judgment, euphoria, visual impairment, drowsiness, lightheaded/dizzy sensation, tingling in the fingers and toes, numbness, pale/clammy appearance, muscle spasms.
Treatment	Must restore proper CO2 level in body. If using supplemental oxygen, check equipment/flow rate to ensure symptoms are not hypoxia-related. Breath normally (prevention and cure), breathe into a paper bag, talk aloud to overcome hyperventilation. Rapid recovery once breathing rate is returned to normal.
Middle ear problems	Middle ear—small cavity located in the bone of the skull. Normally, pressure differences between the middle ear and the outside world are equalized by the Eustachian tube—a tube leading from inside each ear to the back of the throat on each side. The tubes are usually closed, but they open during chewing, yawning, or swallowing, to equalize pressure. The difference between the pressure of the air outside the body, and the air inside the middle air and nasal sinuses, can be extremely painful and can damage the eardrums, and temporarily reduce hearing sensitivity.
Relation to flying	During a climb, the middle air pressure may exceed the pressure of the air in the external ear canal, causing the ear drum to bulge outward. During a descent, the reverse happens—while the pressure of the air in the external ear canal increases, the middle ear cavity (which equalized with the lower pressure at altitude) is at a lower pressure than the external ear canal. The higher outside pressure causes the ear drum to bulge inward.
Treatment	May be difficult to relieve—partial vacuum tends to constrict the walls of the Eustachian tube. Pinch nostrils shut, close lips/mouth, blow slowly and gently in mouth and nose—forces air through the Eustachian tube into the middle ear. May not be possible to equalize pressure in ears if the pilot has a cold, an ear infection, or a sore throat. If experiencing minor congestion, nose drops or nasal sprays may reduce the chance of painful ear blockage.

Sinus problems	Air pressure in the sinuses equalizes with the pressure in the cockpit through small openings that connect the sinuses to the nasal passages. Upper respiratory infections (cold or sinusitis) or a nasal allergic condition can produce enough congestion around an opening to slow equalization.
Symptoms	Excruciating pain over the sinus area. A maxillary sinus block can make the upper teeth ache. Bloody mucus may discharge from the nasal passages.
Relation to flying	As the difference in pressure between the sinus and the cockpit increases, congestion may plug the opening. The "sinus block" occurs most often during descents.
Treatment	Slow descent rates can reduce the associated pain. Can be avoided by not flying with an upper respiratory infection or nasal allergic condition.
Spatial disorientation	Orientation—the awareness of the position of the aircraft and of oneself in relation to a specific reference point. Disorientation—the lack of orientation. Spatial disorientation—the lack of orientation with regards to the position, attitude, or movement of the airplane in space. To ascertain orientation and movement in space, the body uses three integrated systems working together. Most of the time, the three streams of information agree—information comes together in the brain, giving a clear idea of where and how the body is moving. ✈ Visual—the eye (by far the largest source of information) ✈ Postural—the sensation of position, movement, and tension, perceived through nerves, muscles, and tendons. ✈ Vestibular system—a very sensitive motion sensing system located in the inner ears; reports head position, orientation, and movement in 3D space.
Relation to flight	Flying can cause the three systems to provide conflicting information to the brain, leading to disorientation.
Visual system (eyes)	During flight in VMC, the eyes are the major meteorological source, and usually prevail over false sensations from other systems. During flight in IMC, visual cues are taken away, and false sensations can cause a pilot to become disoriented.
Vestibular system (ears)	The vestibular system in the inner ear allows the pilot to sense movement and determine orientation in the surrounding

environment. There are two major parts that are concerned with orientation: semicircular canals, and otolith organs.

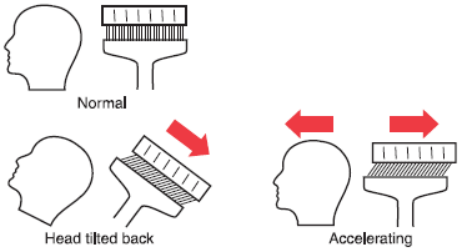
Semicircular canals detect angular acceleration—three tubes at right angles to each other each on one of three axes: pitch, roll, and yaw. Each canal is filled with Endolymph fluid. The cupola, in the center of the canal, is a gelatinous structure that rests upon sensory hairs located at the end of the vestibular nerves.



Semicircular canal in a turn:
When the ear canal is moved in its plane, the relative motion of the fluid moves the cupola. In a turn, the cupola stimulates the sensory hairs to provide the sensation of turning.
The ear is designed to detect turns of a rather short duration—after approximately 20 seconds, the fluid accelerates due to friction between the fluid and the canal wall. Eventually, the fluid moves at the same speed as the ear canal, and the sensory hairs detect no relative movement—the sensation of turning stops. When the aircraft stops turning, the ear canal stops moving, but the fluid does not. The motion of the fluid moves the cupola, and therefore the sensory hairs, in the opposite direction—creates the sensation of turning in the opposite direction even though the turn has stopped.

Otolith organs detect linear acceleration/gravity. Gelatinous membrane, containing chalk-like crystals, covers sensory hairs. When a pilot tilts their head, the weight of the crystals causes the

membrane to shift due to gravity. The brain orients this new position to what it perceives as vertical.



Forward acceleration gives the illusion of the head tilting backward.

Postural system (nerves)

Nerves in body's skin, muscles, and joints, constantly send signals to the brain regarding the body's relation to gravity. Acceleration felt as pilot is pushed back into seat.

- Forces created in turns can lead to false sensations of the true direction of gravity, may give the pilot a false sense of which way is up.
- Uncoordinated turns (especially climbing turns) can cause misleading signals to be sent to the brain.
- Skids/slips give the sensation of banking or tilting.
- Turbulence can create motions that confuse the brain.
- Fatigue or illness can exacerbate these sensations and ultimately lead to subtle incapacitation.

To counteract false sensations—recognize the problem, disregard the false sensations, use the eyes to determine the aircraft attitude while relying totally on the flight instruments. Need to understand the problem and have the self-confidence to control the aircraft using only instrument indications.

Motion sickness

Caused by the brain receiving conflicting messages about the state of the body.
Can also be caused by anxiety and stress.

Symptoms

General discomfort, nausea, dizziness, paleness, sweating, vomiting

Treatment

Open fresh air vents, focus on objects outside the airplane, avoid unnecessary head movement. It generally goes away after a few flight lessons, as the student gets more used to flying and stress/anxiety are reduced.

Carbon monoxide poisoning

CO—colorless, odorless gas, produced by all internal combustion engines. Aircraft heater and defrost vents provide a passageway into the cabin for CO, especially if the engine exhaust has a leak or is damaged.

CO attaches itself to hemoglobin in the blood—about 200 times easier to attach than oxygen. Prevents hemoglobin from carrying oxygen to cells, resulting in hypemic hypoxia. Body can take up to 48 hours to dispose of CO. If poisoning is severe enough, it can result in death.

Effects

Headache, blurred vision, dizziness, drowsiness, loss of muscle power

Detecting and correcting

If a strong odor of exhaust gases is detected, assume CO is present. However, CO may be present even if no exhaust odor is detected. Take immediate corrective actions—turn off the heater, open fresh air vents and windows, and use supplemental oxygen if available.

Stress

Stress—the body's reaction to physical and psychological demands placed upon it.
The body reacts by releasing chemical hormones (e.g. adrenaline) into the blood, increasing metabolism to provide more energy to the muscles, and increasing blood sugar, heart rate, respiration, blood pressure, and perspiration.

Stressors
- Physical stress (noise, vibration)
- Physiological stress (fatigue)
- Psychological stress (difficult work or personal situations)

Stress can be acute (short term) or chronic (long term).
Acute stress involves an immediate threat that is perceived as danger. Triggers a "fight or flight" response from an individual. Normally, a healthy person can cope with acute stress and prevent stress overload. On-going acute stress can develop into chronic stress.
Chronic stress is a level of stress that presents an intolerable burden, exceeds the ability of an individual to cope, and causes individual performance to fall sharply. Can be caused by unrelenting psychological pressures (loneliness, financial worries, relationship or work problems). Pilots experiencing chronic stress are not safe and should not exercise their airman privileges.

Fatigue

Effects of fatigue include degradation of attention and concentration, impaired coordination, and a decreased ability to communicate.

	Caused by sleep loss, exercise, and physical work. Stress, and prolonged performance of cognitive work can cause mental fatigue. Fatigue can be acute (short term) or chronic (long term). Stay on the ground if suffering from acute fatigue, and seek treatment by a physician if suffering from suspected chronic fatigue. Fatigue in the cockpit cannot be overcome through training or experience. To prevent fatigue, get adequate rest and avoid flying without a full night's rest, after working excessive hours, or after an especially exhausting or stressful day.
Acute fatigue	Normal occurrence in everyday life, e.g. the tiredness felt after a period of strenuous effort, excitement, or lack of sleep. Skill fatigue is a special type of acute fatigue that affects performance. Timing disruption—appearing to perform a task as usual, but the timing of each component is slightly off. Makes the operation pattern less smooth, and each component is performed as if it is separate instead of part of an integrated activity. Perceptual field disruption—concentrating attention upon movements or objects in the center of vision and neglecting those in the periphery, may be accompanied by loss of accuracy and smoothness in control movements. Can be caused by mild hypoxia, physical stress, psychological stress, or depletion of physical energy resulting from psychological stress. To prevent it, maintain a proper diet to prevent the body from having to consume its own tissues as an energy source, and get adequate rest and sleep to maintain the body's storage of vital energy.
Chronic fatigue	Fatigue extending over a long period of time; usually has psychological roots, although an underlying disease can be sometimes responsible. Symptoms: weakness, tiredness, palpitations of the heart, breathlessness, headaches, irritability, stomach/intestinal problems, generalized aches and pains throughout the body, emotional illness. Usually requires treatment by a physician.
Dehydration	Critical loss of water from the body. First noticeable effect is fatigue, making top physical and mental performance difficult, if not impossible.

	Flying for long periods of time during hot summer temperatures or at high altitudes increases the susceptibility of dehydration—dry air at altitude tends to increase the rate of water loss from the body. If the fluid is not replaced, fatigue can progress to dizziness, weakness, nausea, tingling of the hands and feet, abdominal cramps, and extreme thirst. To prevent, carry and use water frequently on any long flight, whether thirsty or not. If the airplane has a canopy or roof window, wear light colored and porous clothing and a hat. Keep the cockpit well ventilated.
Alcohol and other drugs	Hangovers can impair pilots, by making them more susceptible to disorientation and hypoxia. "Eight hours bottle to throttle." Medications can affect pilot performance. Side effects of medication may impair judgment, coordination, and vision. Anything that depresses the nervous system can make the pilot more susceptible to hypoxia. Do not fly while taking any medication, unless approved by the FAA.
Scuba diving	Provide the body with enough time to rid itself of excess nitrogen absorbed from diving, otherwise decompression sickness can occur, creating an in-flight emergency. Bubbles can end up in the bloodstream. Wait at least 12 hours after a dive which did not require a controlled ascent before flight altitudes up to 8,000', and at least 24 hours after a dive that required a controlled ascent. For flights above 8,000', wait at least 24 hours.
I'M SAFE	Pilot's personal checklist: **I**llness **M**edical **S**tress **A**lcohol **F**atigue **E**motion

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.

CFI PTS

Objective: To determine that the applicant exhibits instructional knowledge of the elements related to aeromedical factors by describing:

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 incurred during scuba dives, and how this affects pilots and passengers during flight.

PPL ACS

Task	***H. Human Factors***
References	FAA-H-8083-2, FAA-H-8083-25; AIM
Objective	To determine that the applicant exhibits satisfactory knowledge, risk management, and skills associated with personal health, flight physiology, aeromedical and human factors, as it relates to safety of flight. ***Note:*** *See Appendix 6: Safety of Flight.*
Knowledge	The applicant demonstrates understanding of:
PA.I.H.K1	The symptoms (as applicable), recognition, causes, effects, and corrective actions associated with aeromedical and physiological issues including: ***Note:*** *If K1 is selected, the evaluator must assess the applicant's knowledge of at least three of the following sub-elements.*
PA.I.H.K1a	a. Hypoxic hypoxia due to altitude increase or oxygen displacement
PA.I.H.K1b	b. Hyperventilation
PA.I.H.K1c	c. Middle ear and sinus problems
PA.I.H.K1d	d. Spatial disorientation
PA.I.H.K1e	e. Motion sickness
PA.I.H.K1f	f. Carbon monoxide poisoning and other forms of hypemic hypoxia
PA.I.H.K1g	g. Stress
PA.I.H.K1h	h. Fatigue
PA.I.H.K1i	i. Dehydration and nutrition
PA.I.H.K1j	j. Hypothermia
PA.I.H.K1k	k. Optical illusions
PA.I.H.K1l	l. Dissolved nitrogen in the bloodstream after scuba dives
PA.I.H.K2	Regulations regarding use of alcohol and drugs.
PA.I.H.K3	Effects of alcohol, drugs, and over-the-counter medications.
PA.I.H.K4	Aeronautical Decision-Making (ADM).
Risk Management	The applicant demonstrates the ability to identify, assess and mitigate risks encompassing:
PA.I.H.R1	Aeromedical and physiological issues.
PA.I.H.R2	Hazardous attitudes.
PA.I.H.R3	Distractions, loss of situational awareness, and/or improper task management.
Skills	The applicant demonstrates the ability to:
PA.I.H.S1	Describe symptoms (as applicable), recognition, causes, effects, and corrective actions for at least three of the conditions listed in K1a through K1l above.
PA.I.H.S2	Perform self-assessment, including fitness for flight and personal minimums, for actual flight or a scenario given by the evaluator.

CPL ACS

Task	*H. Human Factors*
References	FAA-H-8083-2, FAA-H-8083-25; AIM
Objective	To determine that the applicant exhibits satisfactory knowledge, risk management, and skills associated with personal health, flight physiology, aeromedical, and human factors, as it relates to safety of flight. ***Note:*** *See Appendix 6: Safety of Flight.*
Knowledge	The applicant demonstrates understanding of:
CA.I.H.K1	The symptoms (as applicable), recognition, causes, effects, and corrective actions associated with aeromedical and physiological issues including: ***Note:*** *If K1 is selected, the evaluator must assess the applicant's knowledge of at least three of the following sub-elements.*
CA.I.H.K1a	a. Hypoxic hypoxia due to altitude increase or oxygen displacement
CA.I.H.K1b	b. Hyperventilation
CA.I.H.K1c	c. Middle ear and sinus problems
CA.I.H.K1d	d. Spatial disorientation
CA.I.H.K1e	e. Motion sickness
CA.I.H.K1f	f. Carbon monoxide poisoning and other forms of hypemic hypoxia
CA.I.H.K1g	g. Stress
CA.I.H.K1h	h. Fatigue
CA.I.H.K1i	i. Dehydration and nutrition
CA.I.H.K1j	j. Hypothermia
CA.I.H.K1k	k. Optical illusions
CA.I.H.K1l	l. Dissolved nitrogen in the bloodstream after scuba dives
CA.I.H.K2	Regulations regarding use of alcohol and drugs.
CA.I.H.K3	Effects of alcohol, drugs, and over-the-counter medications.
CA.I.H.K4	Aeronautical Decision-Making (ADM).
Risk Management	The applicant demonstrates the ability to identify, assess and mitigate risks, encompassing:
CA.I.H.R1	Aeromedical and physiological issues.
CA.I.H.R2	Hazardous attitudes.
CA.I.H.R3	Distractions, loss of situational awareness, and/or improper task management.
Skills	The applicant demonstrates the ability to:
CA.I.H.S1	Describe symptoms (as applicable), recognition, causes, effects, and corrective actions for at least three of the conditions listed in K1a through K1l above.
CA.I.H.S2	Perform self-assessment, including fitness for flight and personal minimums, for actual flight or a scenario given by the evaluator.