1. Characteristics of Hypoxia (2-16)

- Hypoxia results when the body lacks oxygen.
- Hypoxia tends to be associated only with flights at high altitudes. However, other factors such as alcohol abuse, heavy smoking and various medications interfere with the blood’s ability to absorb oxygen.
- These factors can either diminish the ability of the blood to absorb oxygen or reduce the body’s tolerance to hypoxia.

2. Types of Hypoxia (2-16)

- **Hypoxic**
- **Hypemic**
- **Stagnant**
- **Histotoxic**

**Hypoxic Hypoxia (2-16)**

- Occurs when not enough oxygen is in the air or when decreasing atmospheric pressures prevent the diffusion of O2 from the lungs to the bloodstream.
- Aviation personnel are most likely to encounter this type of hypoxia at altitude. It is due to the lack of PO2 at high altitudes.

**Hypemic Hypoxia (2-16)**

- Hypemic or anemic hypoxia is caused by a reduction in the oxygen carrying capacity of the blood.
- Anemia and blood loss are the most common causes of this type.
- Carbon monoxide, nitrites and sulfa drugs also cause this hypoxia by forming compounds with hemoglobin and reducing the hemoglobin that is available to combine with oxygen.

**Stagnant Hypoxia (2-17)**

- The oxygen carrying capacity of the blood is adequate but, circulation is inadequate.
- Such conditions a heart failure, arterial spasm, and occlusion of the blood vessel.
- More often, a crewmember experiences extreme gravitational forces, disrupting and causing the blood to stagnate.
Histotoxic Hypoxia (2-17)

- This results when there is interference with the use of oxygen by body tissues.
- Alcohol, narcotics and certain poisons such as cyanide interfere with the cells’ ability to use an adequate supply of oxygen.

3. Effects of Hypoxia (2-20)

- In aviation, the most important effects of hypoxia are those either directly or indirectly, to the nervous system.
- A prolonged or severe lack of oxygen destroys brain cells.

4. Stages of Hypoxic Hypoxia (2-21)

- Indifferent
- Compensatory
- Disturbance
- Critical

Indifferent Stage (2-21)

- Mild hypoxia in this stage causes night vision to deteriorate at about 4,000’. At this point there is a significant decrease in visual acuity, which is cause both by the dark conditions and the developing mild hypoxia.
- This condition occurs between 0 and 10,000’
- Oxygen saturation in this stage is 90%-98%

Compensatory Stage (2-22)

- The circulation system and to a lesser degree the respiratory system provide some defense against hypoxia at this stage.
- The pulse rate, systolic blood pressure, circulation rate and cardiac output increase.
- At 10,000 to 15,000’ however the effects of hypoxia on the nervous system become increasingly apparent.
- After 10 to 15 minutes, impaired efficiency is obvious. Crewmembers become drowsy and make frequent errors in judgment.
- At this point they may also find even the simple tasks requiring alertness and muscular coordination difficult to perform.
- Oxygen saturation in this stage occurs at 80%-89%.

Disturbance Stage (2-22)

- In this stage the physiological responses can no longer compensate for the oxygen deficiency.
- Occasionally crewmembers become unconscious during this stage.
- Other symptoms are fatigue, sleepiness, dizziness, headache, breathlessness and euphoria.
This condition occurs between 15,000 and 20,000’
Oxygen saturation in this stage is between 70%-79%.
Additional considerations during this stage:
- Peripheral vision and central vision are impaired and visual acuity is diminished
- Weakness and loss of muscular coordination are experienced.
- Sensation of touch and pain are diminished or lost
- Thinking is slow and calculations are unreliable.
- Short-term memory is poor and judgment and reaction time is affected.
- Euphoria, aggressiveness, overconfidence or depression can occur.
- When cyanosis occurs, the skin becomes bluish in color.

Critical Stage (2-23)

- Within three to five minutes, judgment and coordination usually deteriorate.
- Subsequently, mental confusion, dizziness incapacitation and unconsciousness occur.
- This occurs between 20,000 and 25,000’
- Oxygen saturation occurs at 60%-69%.

5. Prevention of Hypoxic Hypoxia (2-23)

- Hypoxic hypoxia is the type of hypoxia most often encountered in aviation.
- Hypoxic hypoxia can be prevented by ensuring that sufficient oxygen is available.
- Prevention measures include:
  - Limiting the time at altitude
  - Using supplemental oxygen
  - Pressurizing the cabin
- The prevention of hypoxic hypoxia is essential in the aviation environment.
- There are, however, other causes of hypoxia.
  - Carbon monoxide uptake (hypemic hypoxia)
  - Effects of alcohol (histotoxic hypoxia)
  - Reduced blood flow (stagnant hypoxia)
- Avoiding or minimizing self-imposed stressors helps eliminate hypoxic conditions.

6. Treatment of Hypoxia (2-24)

- Treatment consists of giving 100% oxygen immediately.
- If oxygen is not available, descent do an altitude below 10,000’ is mandatory
- When symptoms persist, the type and cause of the hypoxia must be determined and treatment administered.

7. Trapped-Gas Disorders (2-26)

- During ascent, the free gas normally present in various body cavities expands.
- If the escape of this expanded volume is impeded, pressure builds up within the cavity and pain is experienced.
8. Trapped-Gas Disorders of the Ears (2-28)

- When ascending to altitude, aircrew members often experience physiological discomfort during changes in atmospheric pressure.
- As the pressure decreases during ascent, the expanding air in the middle ear is intermittently released through the eustachian tube into the nasal passages.
- As the inside pressure increases, the eardrum bulges until an excess pressure of about 12 to 15 mm/Hg is reached. At this time, the air trapped in the middle ear is forced out of the middle ear and the eardrum resumes its normal position.
- Just before the air escapes into the eustachian tube, there is a sensation of fullness in the ear. As the pressure is released, there is often a click or pop.

**During Flight:**
- During the descent, the change in pressure within the ear may not occur automatically.
- Equalizing the pressure in the middle ear with that of the outside air may be difficult.
- The eustachian tube allows air to pass outward easily but resists passage in the opposite direction.
- With the increase in barometric pressure during descent, the pressure of the external air is higher than the pressure in the middle ear and the eardrum is pushed in.
- This painful condition could cause the eardrum to rupture.
- If the pain increases with further descent, ascending to a level to which the pressure can be equalized may provide the only relief.
- A slower descent is recommended.

9. Prevention and Treatment (2-30)

**During Flight:**
- Normally, crewmembers can equalize pressure during descent by swallowing or yawning or by tensing the muscles of the throat.
- If these methods do not work, they can perform the Valsalva maneuver.
- To do this, they close the mouth and pinch the nose shut, and blow sharply. This maneuver forces air through the previously closed Eustachian tube in the cavity of the middle ear; pressure will equalize.

**NOTE:** To avoid overpressurization of the middle ear, crewmembers should never attempt a valsalva maneuver during ascent.

**After Flight:**
- If the pressure has not equalized and landing and the condition persists, aviation personnel should consult a flight surgeon.
10. Stress Defined (3-1)

Stress is the nonspecific response of the body to any demand placed upon it.

- This definition incorporates two very important basic points: stress is a physiological involving actual changes in the body’s chemistry and function, and stress involves some perceived or actual demand for action.
- These demands can be either positive or negative because both types of demands may be stressful.

11. Identifying Stressors (3-1)

- A stressor is any stimulus or event that required an individual to adjust or adapt in some way – emotionally, physiologically or behaviorally.
- Stressors may be *psychosocial*, *environmental*, *physiological* and *cognitive*.

**Psychosocial Stressors (3-1)**

- Psychosocial stressors are life events.
- They may trigger adaptation or changes in lifestyle, career, and/or interaction with others.
- Examples of the psychosocial stressors are job stress, illness, or family issues.

**Environmental Stressors (3-2)**

- Examples of environmental stressors are: altitude, speed, hot and cold, aircraft design, airframe characteristics, and instrument flight conditions.

**Physiological (Self-Imposed) Stressors (3-3)**

- Although aircrew members often have limited control over many aspects of aviation-related stress, they can exert significant control over self-imposed stressor.
- Many aviators engage in maladaptive behaviors that are potentially debilitating and threaten aviation safety.
- This category can be related to the acronym DEATH, which stands for *drugs*, *exhaustion*, *alcohol*, *tobacco* and *hypoglycemia*. 
Drugs (3-4)

- In general, no crewmember taking medication is fit to fly unless a flight surgeon has specifically cleared the crewmember to fly.
- Most drugs, whether prescribed or over the counter, have unwanted side effects that may very from person to person.
- Caffeine is commonly ingested by many people. However, it is a drug potentially negative effects on flight operations if not used properly and in moderation.
- Caffeine is a nervous system stimulant that counteracts and delays drowsiness and fatigue.

Exhaustion (3-7)

- Aircrew members require adequate rest and sleep to ensure optimal performance.
- Lack of exercise impairs circulatory efficiency, reduces endurance, and increases the likelihood of illness.
- Sports that require agility, balance and endurance are an excellent means of keeping the body and mind in top form.

Alcohol (3-7)

- Moderate ingestion of alcohol usually causes no problems. However in the aviation environment alcohol can be deadly.
- Alcohol acts as a depressant and adversely affects normal body functions. Even a small amount has a detrimental effect on judgment, perception, reaction time, impulse control and coordination.
- Alcohol reduces the ability of brain cells to use oxygen.
- After drinking alcohol, an aviator should wait at least 12 hours before beginning flying duties. Side effects of alcohol are dangerous. If side effects are present, the nonflying period should be extended beyond 12 hours.

Tobacco (3-8)

- Although the aviator should be concerned about the long term effects of smoking, they should be just as concerned about the acute effect of carbon monoxide produced by smoking tobacco.
- The average cigarette smoker adds about 5,000’ to their physiological altitude.
- Cigarette smoking also decreases night vision.
- A nonsmoking pilot begins to experience decreased night vision at 4,000’ to 5,000’ of altitude because of hypoxia; but a smoking pilot begins at sea level with a physiological night-vision deficit of 5,000’.
Hypoglycemia (3-8)

- Missing meals or substituting a quick snack and coffee for a balanced meal can induce fatigue and inefficiency. The body requires periodic refueling to function. Normal, regular eating habits are important.
- Because of mission requirements, aircrews often disrupt their regular eating habits and skip meals.
- This disruption can lead to hypoglycemia. This occurs due to the low blood-sugar level in the body, caused by poor eating habits.

Cognitive Stressors (3-9)

- How one perceives a given situation or problem is a potentially significant and frequently overlooked source of stress.
- Pessimism, obsession, failure to focus on the present, and/or low self-confidence can create a self-fulfilling prophecy that will ensure a negative outcome.

12. The Stress Response (3-10)

- Stress affects individuals in a variety of ways. These effects may include emotional, behavioral, cognitive (thoughts), and physical responses.

Emotional Responses to Stress (3-10)

- Emotional responses may range from increased anxiety, irritability, or hostility to depressed mood, loss of self-esteem, hopelessness and an inability to enjoy life.
- If emotional responses are severe and interfere significantly with social or occupational functioning, crewmembers should consult the flight surgeon.
- Aviators and other aviation personnel often shy away from seeking help for emotional problems, but it is important to recognize that stress can become overwhelming at times and present a serious threat to aviation safety.

Behavioral Response to Stress (3-10)

- High stress can adversely affect one’s work performance, decrease motivation, and increase the likelihood of conflict, insubordination and violence in the workplace.
- This can result in the individuals becoming socially isolated, while others may turn to alcohol or drug abuse.
Cognitive Response to Stress (3-10)

- Stress can significantly affect one’s thought processes.
- It can decrease attention and concentration, interfere with judgment and problem solving, and impair memory.
- Stress can cause aviators to commit thinking errors and to take mental shortcuts that could be potentially fatal.
- Many individuals under high-stress conditions will forget learned procedures and skills and revert to bad habits.

Physical Response to Stress (3-11)

- The immediate physical response to a stressful situation involves overall heightened arousal of the body.
- This may include increased heart rate, increased blood pressure, more rapid breathing, tensing of the muscles, and the release of sugars and fats into circulation to provide fuel for “fight or flight”.
- Prolonged stress and continuous effects on the body may produce longer-term physical symptom such as muscle tension and pain, headaches, high blood pressure, gastrointestinal problems and decreased immunity to infectious disease.

13. Stress Under Load (3-11)

- Having too little stress can be as dysfunctional as having too much stress.
- A lack of challenges can lead to complacency, boredom and impulsive risk taking.
- The effects of stress under load are of particular concern in peacekeeping operations. In these operations, soldiers will often have a considerable amount of unstructured time and work tasks can become routine and monotonous.

14. Stress and Performance (3-11)

- The relationship between stress and performance depends on a variety of factors.
- The mental skills required by the task or situation, the stress characteristics of the situation, physical characteristics of the individual and the psychological makeup of the individual.

Mental skills required by the task or situation. (3-12)

- The degree to which a given task or situation requires specific cognitive skills – such as attention, concentration, memory, problem solving, or visual-spatial orientation – will influence the extent to which stress will degrade performance.
- Performance in situations involving simple mental tasks tend to be less affected by stress than by those tasks requiring more complex cognitive skills.
**Stress characteristics of the situation. (3-12)**

- The environment and conditions under which a given task is to be performed also affects the performance.

**Physical Characteristics of the Individual (3-12)**

- The individual differences in strength, endurance, and physical health greatly influence the extent to which stress affects performance.

**Psychological Makeup of the Individual (3-12)**

- Mental health, much like physical health, serves to moderate the effects of stress on performance. Individuals with good coping, problem solving and social skills will perform much better under stress than those who are weaker in these areas.

**15. Stress Management (3-12)**

Stress coping mechanisms are the psychological and behavioral strategies for managing the external and internal demands imposed by stressors. Coping mechanisms can be characteristics according to the following categories.

- **Avoiding stressors**
- **Changing your thinking**
- **Learning to relax**
- **Ventilating stress**

**Avoiding Stress (3-12)**

- This is the most powerful coping mechanism.
- Crewmembers can avoid stressors with good planning, foresight, realistic training, good time management and effective problem solving.
- Good crew coordination and communication—including asking questions, using three-way confirm responses, and briefing lost communications—also serve to avoid flight stress.

**Changing your thinking (3-13)**

- How you perceive your environment and choose to think about yourself and others greatly affect your stress level and performance.
- Crewmembers may greatly enhance their stress management and personal effectiveness by-
  - Practicing positive self talk
  - Taking responsibility for their actions
  - Recognizing the choices that they make
Avoiding perfectionism and inflexibility in thinking
• Focusing on the here and now rather than on the past or future

Learning to Relax (3-13)

➢ Relaxation is incompatible with stress.
➢ It is impossible to be relaxed and anxious at the same time.
➢ Learning and regularly practicing relaxation techniques, breathing exercises, or meditation or regularly engaging in a quiet hobby greatly reduce stress.
➢ Making time to relax during a busy schedule is perhaps the biggest obstacle to this coping strategy.

Ventilating Stress (3-13)

➢ This normally involves blowing off steam in some manner, either through talking or vigorous exercise.

16. Fatigue (3-13)

**Fatigue is the state of feeling tired, weary, or sleepy that results from prolonged mental or physical work, extended periods of anxiety, exposure to harsh environments, or loss of sleep.**

➢ Boring or monotonous tasks may increase fatigue.
➢ Crewmembers may not become aware of fatigue until they make serious errors.
➢ Sleep deprivation, disrupted diurnal cycles, or life-event stress may all produce fatigue and concurrent performance decrements.

The types of fatigue are **acute, chronic,** and **motivational exhaustion, or burnout.**

**Acute Fatigue (3-13)**

➢ This type of fatigue is associated with either physical or mental activity which occurs between two regular sleep cycles.
➢ The loss of both coordination and awareness of errors is the first type of fatigue to develop.
➢ Acute fatigue is characterized by—
  • Inattention
  • Distractibility
  • Errors in timing
  • Neglect of secondary tasks
  • Loss of accuracy and control
  • Irritability
**Chronic Fatigue (3-14)**

- *This type of fatigue is more serious* and occurs over a longer period and is typically the result of inadequate recovery from successive periods of acute fatigue.
- Besides physical tiredness, mental tiredness also develops.
- It may take several weeks of rest to completely eliminate chronic fatigue; and there may be underlying social causes, such as family or financial difficulties that must be addressed before any amount of rest will help the person recover.
- Chronic fatigue is characterized by—
  - Insomnia
  - Depressed mood
  - Irritability
  - Weight loss
  - Poor judgment
  - Loss of appetite
  - Slowed reaction time
  - Poor motivation and performance on the job

**Motivation Exhaustion or Burnout (3-14)**

- If chronic fatigue proceeds untreated for too long, the individual will eventually “shut down” and cease functioning occupationally and socially.
- Motivational exhaustion is also known as burnout.

**17. Effects of Fatigue on Performance (3-14)**

- Reaction Time Changes
- Reduced Attention
- Diminished Memory
- Changes in Mood and Social Interaction
- Impaired Communication

**Reaction Time Changes (3-14)**

- Fatigue can result in either increases or decreases in reaction time.
- Increases occur because of the general decrease in motivation and sluggishness that often accompany fatigue.
- Decreases in reaction time may also occur, however, when individuals become impulsive and react quickly and poorly.
Reduced Attention (3-15)

- There is a tendency to overlook or misplace sequential task elements (such as forgetting items on preflight checklist)
- Preoccupation with single tasks or elements (such as paying too much attention to a bird and forgetting to fly the aircraft)
- Reduction of scan both inside and outside the cockpit
- Lack of awareness of poor performance

Diminished Memory (3-15)

- Short-term memory capacity decreases although long-term memory tends to be unaffected. Integrating new information and making decisions becomes more challenging, as does adaptability to change in general.
- Inaccurate recall of operational events (such as objective rally points)
- Neglect of peripheral tasks (forgetting to check landing gear down)
- Tendency to revert to old bad habits
- Decreased ability to integrate new information and analyze and solve problems

Changes in Mood and Social Interaction (3-15)

- Fatigue individuals may become irritable and combative.
- They may also experience mild depression and withdraw socially.

Impaired Communication (3-15)

- Fatigue impairs one’s ability to both communicate and receive information.
- Individuals may leave out important details in the messages that they send to others.
- They may also fail to attend completely or information they receive, or they may misinterpret the information.
- Fatigue can also affect a crewmembers pronunciation, rate of speech, tone or volume.
18. Diurnal (Circadian) Rhythms and Fatigue (3-15)

- We have a biological clock that cycles roughly every 24 to 25 hours. This clock is important to many of our bodily functions such as body temperature, alertness, heart rate, and sleep cycle.
- This cycle basically is peaked out between 0800-1200 and 1500-2100 hours daily. We tend to experience slight drop off periods between 1300-1500 and then fall off to a minimum between 0300-0600.
- This body clock is flexible and must be set. Some of the things that can assist in synchronizing our body clock are—
  - Sunrise and sunset
  - Ambient temperature
  - Meals and social cues

19. Prevention of Fatigue (3-17)

- Total prevention of fatigue is impossible, but its effects can be significantly moderated.
- The following recommendations should be considered in any individual or crew-endurance plan—
  - Control of the sleep environment
  - Adjust to shift work
  - Maintain good health and physical fitness
  - Practice good eating habits
  - Practice moderate, controlled use of alcohol and caffeine
  - Plan and practice good time management
  - Practice realistic planning
  - Maintain optimal working conditions
  - Take naps

20. Treatment of Fatigue (3-18)

- The most important action for treating fatigue is to get rest and natural (not drug induced) sleep.
- Measures that can be taken to prevent or treat fatigue are—
  - Modify the workspace to promote rest and prevent any further fatigue
  - Rotate duties to avoid boredom, or change duties
  - Pace yourself and avoid heavy task-loaded activities
  - Limit work periods and delegate responsibility
  - Limit physical activity immediately before task performance. Do not exercise closer than one hour before bedtime
  - Remove yourself from flying duties when fatigue affects flight safety
21. Carbon Monoxide (5-3)

- Carbon monoxide is a product of incomplete combustion.
- It is the most common gaseous poison in the aviation environment.
- The effects of carbon monoxide are subtle and deadly.
- Carbon monoxide results in the production of hypoxia at both sea level and altitude.
- It combines with hemoglobin to the partial exclusion of oxygen and thus interferes with the uptake of oxygen by the blood.
- CO has 256-times greater affinity for bonding with hemoglobin than with oxygen.
- It is a colorless, odorless gas that is lighter than air.
- A relatively low concentration of CO in the air can, in time, produce high concentrations of CO.
- A person who inhales a 0.5% concentration of CO for 30 minutes while at rest will have a 45% blood concentration of CO.
- A reduced concentration of oxygen in the air and increased temperature or humidity may also increase the concentration of CO-bound hemoglobin.
- If an individual inhales air containing CO at 5,000 to 10,000 parts per million, death may result in 2 to 15 minutes.

Effects of carbon monoxide on the body (5-5)

- Tremors
- Headache
- Weakness
- Joint pain
- Hoarseness
- Nervousness
- Muscular cramps
- Muscular twitching
- Loss of visual acuity
- Impairment of speech and hearing
- Mental confusion and disorientation

Symptoms of carbon monoxide (5-5)

- They are similar to those of hypemic hypoxia.
- Of particular importance to aviators is the loss of visual acuity.
- Peripheral vision and, more importantly, night visual acuity is significantly decreased.

Dangers associated with carbon monoxide (5-5)

- The danger rises sharply with increases in altitude.
- Small amounts of carbon monoxide may be harmless, but the effects become additive with additional exposure.
- This effect combined with altitude may cause serious pilot impairment and result in loss of aircraft control.
Treatment when exposed to carbon monoxide (5-5)
When flight personnel suspect the presence of carbon monoxide in the aircraft they should—
  o Turn off exhaust heaters
  o Inhale 100% oxygen (if available)
  o Land as soon as practical
  o After landing, they should investigate the source and evaluate their own possible symptoms of carbon monoxide intoxication.

22. Heat Injury (6-3)

  The body will undergo certain physiological changes to counteract heat stress.
  Normal heavy sweating produces one pint to one quart per hour; heat stress conditions, however, can result in 3 to 4 quarts being produced.
  If a person does not replace this sweat loss by drinking fluids, the body rapidly dehydrates, the rate of sweat production drops, and the body temperature increases, causing further heat injury.

*Individual responses to heat stress (6-3)*

  Some of the serious reactions to heat stress are—
  o *Heat cramps*
  o *Heat exhaustion*
  o *Heatstroke*
  Some of the factors that influence the response are—
  - Amount of work being performed and their physical condition and ability to adapt to the environment
  - Age, weight and previous history of heatstroke
  - Consumption of alcohol
  - Lack of sleep

23. Performance Impairment (6-4)

  Heat stress not only causes general physiological changes but also results in performance impairment.
  Even a slight increase in body temperature impairs an individual’s ability to perform complex tasks such as those required to fly an aircraft safely.
  A body temperature of 101 degrees roughly doubles an aviator’s error rate.
  Generally, increases in body temperature have the following effects on an aviator:
  - *Error rate increase*
  - *Short-term memory becomes less reliable*
  - *Perceptual and motor skills slow, and the capacity to perform aviation tasks decreases*
24. Heat-Stress Prevention (6-4)

By taking certain preventive measures, personnel can avoid heat stress.
- Replace water and salt loss
- Adapt to the environment
- Wear protective clothing

25. In-Flight Heat-Stress Prevention (6-5)

- Army aircrew members are required to work in hot cockpits.
- To minimize the in-flight heat stress potential the following should be considered:
  - Increase ventilation
  - Continue to replace fluids

26. Day Blind Spot (8-6)

- The day blind spot covers an area of 5.5 to 7.5 degrees.
- It is located about 15 degrees from the fovea and originates where the optic nerve attaches to the retina.
- Where the optic nerve attaches to the retina, no photoreceptor cells (cones or rods) are present.
- The day blind spot only causes difficulty when individuals do not move their head or eyes but continue to look straightforward while an object is being brought into the visual field.

*Because we have two eyes and view all images with binocular vision, each eye compensates for the day blind spot in the optic disk of the opposite eye.*

27. Types of Vision (8-6)

- The three types of vision (viewing periods) associated with Army aviation are:
  - Photopic
  - Mesopic
  - Scotopic
- All three require different sensory stimuli or ambient light conditions.

*Photopic Vision (8-7)*

- This type of vision is experienced during daylight or under high levels of artificial illumination.
- The cones concentrated in the fovea centralis are primarily responsible for vision in bright light.
- The eye uses central vision for interpretation, especially for determining details.
Mesopic Vision (8-7)

- This type of vision is experienced at dawn and dusk and under full moon light.
- Vision achieved by a combination of rods and cones.
- Visual acuity steadily decreases with declining light.
- Mesopic vision is the most dangerous of all three types for aircrew members.

Scotopic Vision (8-7)

- This type of vision is experienced under low-light level environments such as partial moonlight and star light conditions.
- Cones become ineffective, causing poor resolution of detail.
- Visual acuity decreases to 20/200 or less and color perception is lost.
- Peripheral vision is primary for viewing with scotopic vision.

28. Spatial Disorientation (9-1)

- This problem contributes more to causing aircraft accidents than any other physiological problem in flight.
- The human body is structured to perceive changes in movement on land in relation to the surface of the earth.
- In flight, the human sensory systems may give the brain erroneous orientation information.
- This can cause sensory illusions, which may lead to spatial disorientation.

Common Terms of Spatial Disorientation (9-1)

- Spatial disorientation
- Sensory illusion
- Vertigo

Spatial Disorientation (9-1)

- This is an individual’s inability to determine his or her position, attitude, and motion relative to the surface of the earth or significant objects; for example, trees, poles or buildings during hover.
- When it occurs, pilots are unable to see, believe, interpret, or prove the information derived from their flight instruments.
- Instead, they rely on the false information that their senses provide.

Sensory Illusion (9-1)

- A sensory illusion is a false perception of reality caused by a conflict of orientation information from one or more mechanisms of equilibrium.
- Sensory illusions are a major cause of spatial disorientation
Vertigo (9-1)

- Vertigo is a spinning sensation usually caused by a peripheral vestibular abnormality in the middle ear.
- Aircrew members often misuse the term vertigo, applying it generically to all forms of spatial disorientation or dizziness.

29. Types of Spatial Disorientation (9-1)

- Type I (Unrecognized)
- Type II (Recognized)
- Type III (Incapacitating)

Type I (Unrecognized) (9-1)

- A disoriented aviator does not perceive any indication of spatial disorientation.
- This is the most dangerous type of disorientation
- The pilot-unaware of a problem fails to recognize or correct the disorientation, usually resulting in a fatal aircraft mishap.
- An example of this type of spatial disorientation would be the height/depth perception illusion when the pilot descends into the ground or some obstacle above the ground because of a lack of situational awareness.

Type II Recognized (9-2)

- During this type of disorientation, the pilot perceives a problem. The pilot, however, may fail to recognize it as spatial disorientation.
- The pilot may feel that a control is malfunctioning
- The pilot may also perceive an instrument failure as in the graveyard spiral.
- The pilot does not correct the roll, as indicated by the attitude indicator, because his vestibular indications of straight-and-level are so strong.

Type III (Incapacitating)

- The pilot experiences such an overwhelming sensation of movement that he or she cannot orient by using visual cues or aircraft instruments.
- This is not fatal if the copilot can gain control of the aircraft.
30. Equilibrium Maintenance (9-2)

- Three sensory systems are especially important to maintaining equilibrium and balance.
  - **Visual**
  - **Vestibular**
  - **Proprioceptive**

- Normally, the combined functioning of these senses maintains equilibrium and prevents spatial disorientation.
- During flight, the visual system is the most reliable.
- In the absence of the visual system, the vestibular and proprioceptive systems are unreliable in flight.

**Visual System (9-3)**

- The visual system is the most important of the three sensory systems in maintaining equilibrium and orientation.

- Eighty (80%) of our orientation information comes from the visual system.
- To some extent, the eyes can help determine the speed and direction of flight by comparing the position of the aircraft relative to some fixed point of reference.
- The eyes allow the pilot to scan sensitive flight instruments that give accurate spatial-disorientation information.

**Vestibular System (9-3)**

- The inner ear contains the vestibular system, which contains the motion and gravity-detecting sense organs.
- The vestibular apparatus consists of two distinct structures: the semicircular canals and the vestibule proper.
- Both the semicircular canals and the otolith organs sense changes in aircraft attitude.
- Only the semicircular canals of the inner ear sense changes in angular acceleration and deceleration.

**Otolith Organs (9-4)**

- The otolith organs are small sacs located in the vestibule.
- The otolith organs respond to gravity and linear acceleration/deceleration.
- Changes in the position of the head, relative to the gravitational force cause the otolith membrane to shift position.
- The sensory hairs bend, signaling a change in head position.
- When the head is tilted, the “resting” frequency is altered and the brain is informed of the new position.
- Linear acceleration/deceleration also stimulates the otolith organs.
- The body cannot physically distinguish between the inertial forces resulting from linear acceleration and the force of gravity.
A forward acceleration results in the backward displacement of the otolithic membranes. When an adequate visual reference is not available, aircrew members may experience an illusion of backward tilt.

**Semicircular Canals (9-6)**

- The semicircular canals of the inner ear sense changes in angular acceleration.
- The canals will react to any changes in roll, pitch, or yaw attitude.

**Proprioceptive System (9-8)**

- This system reacts to the sensation resulting from pressures on the joints, muscles, skin, and from slight changes in the internal organs.
- Forces act upon the seated pilot in flight.
- With training and experience, the pilot can easily distinguish the most distinct movements of the aircraft by the pressures of the aircraft seat against his body.
- The recognition of these movements has led to the term “seat-of-the-pants” flying.

**31. Visual Illusions (9-9)**

- Illusions give false impressions or misconceptions of the actual condition; therefore, aircrew members must understand the type of illusions that can occur and the resulting disorientation.
- Even with the references outside the cockpit and the display of instruments inside, aircrew members must be on the guard to interpret information correctly.
- Some of the illusions that may occur during VFR daytime operations are:
  - Relative-motion illusion
  - False horizon illusion
  - Height-depth perception illusion
  - Structural illusion
  - Size-distance illusion
  - Fascination (Fixation) in flying
  - Flicker vertigo

**Relative-Motion Illusion (9-9)**

- This occurs when you falsely perceive self-motion in relation to the motion of another object.
- The most common example of this illusion is when a car is stopped at a traffic light and another car pulls alongside. The individual that was stopped at the light perceives the forward motion of the second car as his own motion rearward. This results in the individual applying more brake pressure unnecessarily.
- This illusion can be encountered during flight, hover taxi, or hovering over water or tall grass.
**False Horizon Illusion (9-10)**

- This occurs when the aviator confuses cloud formations with the horizon or the ground.
- This illusion occurs when the pilot subconsciously chooses the only reference point available for orientation.
- A sloping cloud deck may be difficult to perceive as anything but horizontal if it extends for any great distance in the pilot’s peripheral vision.
- This illusion can also occur if an aviator looks outside after having given prolonged attention to a task inside the cockpit.

**Height-Depth Perception Illusion (9-10)**

- This is due to a lack of sufficient visual cues and causes an aircrew member to lose depth perception.
- Flying over an area devoid of visual references—such as desert, snow or water—will deprive the aircrew member of his perception of height.
- The aviator, misjudging the aircraft’s true altitude, may fly the aircraft dangerously low in reference to the ground or other obstacles above the ground.
- Flight in an area where the visibility is restricted by fog, smoke or haze can produce the same illusion.

**Structural Illusion (9-11)**

- Structural illusions are caused by the effects of heat waves, rain, snow, sleet or other visual obscurants.
- A straight line may appear curved when it is viewed through the heat waves of the desert.
- The curvature of the aircraft windscreen can also cause structural illusion.
- This illusion is due to the refraction of light rays as they pass through the windscreen.

**Size-Distance Illusion (9-11)**

- This is a false perception of distance from an object or the ground, created when a crewmember misinterprets an unfamiliar object’s size to be the same as an object that he is accustomed to viewing.
- This illusion can occur if the visual cues, such as a runway or trees, are of a different size than expected.
- An aviator making an approach to a larger, wider runway may perceive that the aircraft is too low.
- Conversely, an aviator making an approach to a smaller, narrower runway may perceive that the aircraft is too low.
Fascination (Fixation) In Flying (9-12)

- This illusion can be separated into two categories: task saturation and target fixation.
- Task saturation may occur during the accomplishment of simple tasks within the cockpit. Crewmembers may become so engrossed with a problem or task within the cockpit that they fail to properly scan outside the aircraft.
- Target fixation, commonly referred to as target hypnosis, occurs when an aircrew member ignores orientation cues and focuses his attention on his object or goal; you become so engrossed with something that you forget to fly the aircraft.

Flicker Vertigo (9-13)

- Viewing a flickering light can be both distracting and annoying.
- Flashing anti collision lights, position lights or strobe lights, especially while an aircraft is in the clouds, can also produce this effect.

32. Vestibular Illusion (9-14)

- The vestibular system provides accurate information as long as an individual is on the ground. Once the individual is airborne, however, the system may function incorrectly and cause illusions.
- These illusions pose the greatest problem with spatial disorientation.
- The vestibular illusions can be divided into two types:
  - Somatogyral illusion
  - Somatogravic illusions

Somatogyral Illusions (9-14)

- These illusions are caused when angular accelerations and decelerations stimulate the semicircular canals.
- The illusions that may be encountered in flight are:
  - Leans
  - Graveyard Spins
  - Coriolis Illusions

Leans (9-14)

- This is the most common form of spatial disorientation.
- This illusion occurs when the pilot fails to perceive angular motion.
- During continuous straight-and-level flight, the pilot will correctly perceive that he is straight-and-level.
- However, a pilot rolling into or out of a bank may experience perceptions that disagree with the reading on the attitude indicator.
Graveyard Spin (9-15)

- Usually occurs in fixed wing aircraft.

Coriolis Illusion (9-16)

- Regardless of the type of aircraft flown, the Coriolis Illusion is the most dangerous of all the vestibular illusions. It causes overwhelming disorientation.
- This illusion occurs whenever a prolonged turn is initiated and the pilot makes a head motion in a different geometric plane.
- When a pilot enters a turn and then remains in the turn, the semicircular canal corresponding to the yaw axis is equalized.
- When the head is moved into the geometric plane other than that of the turn, the yaw axis semicircular canal is moved from the plane of rotation to a new plane of nonrotation.
- The fluid slows in that canal, resulting in a sensation of a turn in the direction opposite of the original turn.
- Simultaneously, the two canals are brought within a plane of rotation. And the combined effect is the creation of a new perception of motion in three different planes of rotation: yaw, pitch and roll.
- The pilot experiences an overwhelming head-over-heels sensation.

Somatogravic Illusions (9-17)

- These illusions are caused by changes in linear acceleration and deceleration or gravity that stimulate the otolith organs.

- The three types of Somatogravic Illusions encountered in flight are:
  - Oculogravic Illusion
  - Elevator Illusion
  - Oculoagravic Illusion

Oculogravic Illusion (9-17)

- This type of illusion occurs when an aircraft accelerates or decelerates.
- Inertia from linear accelerations and decelerations cause the otolith organ to sense nose-high or nose-low attitude.
- In linear acceleration, the gelatinous layer, which contains the otolith organ is shifted aft.
- The aviator falsely perceives that the aircraft is in a nose-high attitude-a pilot correcting for this illusion without crosschecking the instruments would most likely dive the aircraft.
- This illusion does not occur if adequate outside references are available.
Elevator Illusion (9-18)

- This illusion occurs during upward acceleration.
- Because of the inertia encountered, the pilot’s eyes will track downward as his body tries, through inputs supplied by the inner ear, to maintain visual fixation on the environment or instrument panel.
- With the eyes downward, the pilot will sense that the nose of the aircraft is rising.
- *This illusion is most common for aviators flying aircraft that encounter updrafts.*

Oculoagragvic Illusion (9-18)

- This illusion is the opposite of the elevator illusion and results from the downward movement of the aircraft.
- Because of the inertia encountered, the pilot’s eyes tend to track upward.
- The pilot’s senses then usually indicate that the aircraft is in a nose-low attitude.
- *This illusion is commonly encountered as a helicopter enters autorotation.*
- The pilot’s usual intuitive response is to add aft cyclic, which decreases airspeed below the desired level.

33. Proprioceptive Illusions (9-18)

- These illusions rarely occur alone.
- They are closely associated with the vestibular system and to a lesser degree with the visual system.
- The proprioceptive information is fed into the central nervous system, but without visual reference, the body only senses being pressed firmly into the seat. Because this sensation is normally associated with climbs, the pilot may falsely interpret it as such.
- Recovering from turns lightens pressure on the seat and creates an illusion of descending.
- This false perception of descent may cause the pilot to adjust the cyclic, which would cause the airspeed to reduce.

34. Prevention of Spatial Disorientation (9-18)

- Spatial disorientation cannot be totally eliminated. However, aircrew members need to remember that misleading sensations from the sensory system are predictable.
- These sensations can happen to anyone because they are due to the normal functions and limitations of the senses.
- All pilots, regardless of the experience level, can experience spatial disorientation.
- To prevent disorientation, aviators should—
  - *Never fly without visual reference points (either actual or artificial horizon)*
  - *Trust your instruments*
  - *Avoid fatigue, smoking, hypoglycemia, and anxiety which all heighten illusion.*
  - *Never try to fly VMC and IMC at the same time.*
35. Treatment of Spatial Disorientation (9-19)

- Spatial disorientation can easily occur in the aviation environment.
- If disorientation occurs, aviators should—
  - Refer to the instrument and develop a good cross-check
  - Delay intuitive action long enough to check both visual references and instruments.
  - Transfer the flight controls to the other pilot if two pilots are in the aircraft. Rarely will both experience disorientation at the same time.