

AEROSPACE PHYSIOLOGY CERTIFICATION EXAM

OBJECTIVES & ARTICLES

2025

Overview

- Section I** Fundamentals of Human Physiology
~30% of Exam Questions
- Section II** Human Performance in Extreme Environments
~40% of Exam Questions
- Section III** Human Performance Optimization
~25% of Exam Questions
- Section IV** Journal Articles from Aerospace Medicine and Human Performance
~5% of Exam Questions

References

- MP: Guyton, A. & Hall, J. (2006). Textbook of medical physiology (11th ed.). Philadelphia, PA: Elsevier Saunders. (*online reference*)
- EP: McArdle, W. & Katch, F. (2015). Exercise physiology: Nutrition, energy, and human performance (8th ed.). Baltimore, MD: Lippincott Williams & Wilkins.
- AM: Davis, J., Johnson, R., Stepanek, J., & Fogarty, J. (2008). Fundamentals of Aerospace Medicine (4th ed.). Baltimore, MD: Lippincott Williams & Wilkins.
- HE1: Pandolf, K. (2001). Medical aspects of harsh environments (Vol. 1). Falls Church, VA: Office of the Surgeon General, United States Army. (*online reference*)
- HE2: Pandolf, K. (2001). Medical aspects of harsh environments (Vol. 2). Falls Church, VA: Office of the Surgeon General, United States Army. (*online reference*)
- WR: Montain, S. & Ely, M. (2010). Water requirements and soldier hydration. Washington D.C.: Borden Institute. (*online reference*)
- FA: Caldwell, J. & Caldwell, J. (2016). Fatigue in aviation: A guide to staying awake at the Stick (2nd ed.). Burlington, VT: Ashgate.
- SP: Buckey, J. (2006). Space physiology. Oxford, England: Oxford University Press.

SECTION I – FUNDAMENTALS OF HUMAN PHYSIOLOGY

UNIT 1: THE PULMONARY SYSTEM & RESPIRATION

- Pulmonary respiration
 - Pulmonary circulation
 - Physical principles of gas exchange
 - Diffusion of oxygen and carbon dioxide across respiratory membrane
 - Transport of oxygen and carbon dioxide in blood and tissue fluids
 - Regulation of respiration
 - Abnormal respiration
 - Abnormal oxygenation
 - Oxygen toxicity
1. Describe the muscular actions associated with pulmonary ventilation (MP)
 2. Describe the pressures that are responsible for moving air in and out of the lungs (MP)
 3. Describe the effects of surface tension and surfactant on pulmonary ventilation (MP)
 4. Describe the functions of the respiratory passageways (MP)
 5. Describe the function of the three parts of the physiologic anatomy of pulmonary circulatory system (MP)
 6. Describe pulmonary artery, pulmonary capillary, and pulmonary venous pressures (MP)
 7. Describe the blood volume of the lungs (MP)
 8. Describe factors that affect blood flow through the lungs (MP)
 9. Describe the three zones of pulmonary blood flow (MP)
 10. Describe the effects of exercise on pulmonary vascular resistance (MP)
 11. Describe factors that affect the fluid dynamics of the pulmonary capillaries (MP)
 12. Describe the causes and effects of pulmonary edema (MP)
 13. Describe the functions of the pleural fluids (MP)
 14. Describe the role of the respiratory centers in the neural control of respiration (MP)
 15. Describe the location of the respiratory center and the role of its three major collections of neurons used in the neural control of respiration (MP)
 16. Describe how sensory signals are transmitted into the respiratory center and the receptors used (MP)
 17. Describe the effects of altered CO₂ on respiratory control and renal response (MP)
 18. Describe the role of the peripheral chemoreceptor system in respiratory control (MP)
 19. Describe factors that affect respiratory control during exercise (MP)
 20. Describe the pulmonary volumes and capacities (MP)
 21. Describe alveolar ventilation and the associated resultant air dead spaces (MP)
 22. Describe the physics of gaseous diffusion (MP)
 23. Describe the composition of alveolar air and the factors that control this composition (MP)
 24. Describe the anatomical structure of the respiratory membrane (MP)
 25. Describe the factors affecting the rate of gaseous diffusion through the respiratory membrane (MP)
 26. Describe the physiological impact of ventilation-perfusion mismatch and the effect of Oxygen Paradox (MP)
 27. Describe the factors that determine the pO₂ and pCO₂ of the pulmonary blood and of the tissues (MP)
 28. Describe the percentages of oxygen transported by red blood cells and plasma of the blood (MP)
 29. Describe the oxygen-hemoglobin dissociation curve and the factors that can cause it to “shift” (MP)
 30. Describe hemoglobin oxygen saturation at various pO₂ levels (MP)

31. Describe the mechanisms by which CO₂ is transported by the blood (MP)
32. Recognize, from a list, the subjective symptoms and objective signs of hypoxia (AM)
33. Discuss the relationship between the loss of atmospheric pressure and the onset of hypoxia (AM)
34. State the effective performance times at 18,000 ft, 25,000 ft, 35,000 ft, and 43,000 ft (AM)
35. List the five steps for the treatment of hypoxia (AM)
36. Describe oxygen toxicity (AM)
37. List the causes of and physiological response to hyperventilation (AM)
38. List the subjective and objective symptoms of hyperventilation (AM)
39. List the steps for treating hyperventilation (AM)

UNIT 2: THE HEART

- Physiology of cardiac muscle
 - The cardiac cycle
 - Work output of the heart
 - Regulation of heart pumping
 - Specialized excitatory and conductive system of the heart
 - Control of excitation and conduction in the heart
 - Cardiac output at rest
 - Cardiac output during physical activity
 - Cardiac output and oxygen transport
1. Describe physiological concerns specific to cardiac muscle (MP)
 2. Describe the cardiac cycle and the role of the atria, ventricles, and valves in each phase of the cardiac cycle (MP)
 3. List and describe the four cardiac fraction/volume measurements (MP)
 4. Describe the Frank-Starling mechanism of cardiac pumping regulation (MP)
 5. Describe the roles of the sinus node, A-V node, A-V bundle, and Purkinje fibers in the control of the cardiac cycle (MP)
 6. Describe rhythmical excitation of the heart (MP)
 7. Describe the effects of parasympathetic and sympathetic stimulation on cardiac function (MP)
 8. Describe the source of energy required for heart muscle contraction (MP)
 9. Describe cardiac output (EP)
 10. Describe cardiac output during rest and physical activity (EP)
 11. Describe the effects of prolonged physical activity on cardiac output (EP)

UNIT 3: THE CIRCULATION

- Physical characteristics of the circulation
- Basic theory of circulation
- Vascular distensibility
- Veins and their function
- Structure of the microcirculation and capillary system
- Flow of blood in the capillaries
- Exchange of water, nutrients, and other substances between blood and interstitial fluid
- Neural regulation of the circulation

1. Describe physical characteristics of the circulation; define medical physics of pressure, flow, and resistance (MP)
2. Describe the function of arterial system (MP)
3. Describe the basic theory of circulation and the relationship among pressure, flow, and resistance (MP)
4. Describe vascular distensibility (MP)
5. Describe the function of venous system (MP)
6. Describe the local and humoral control of blood flow by the tissues (MP)
7. Describe the nervous regulation of the circulation and rapid control of arterial blood pressure (MP)
8. Describe the role of the kidney in controlling blood pressure (MP)
9. Describe cardiac output, venous return, and their regulation (MP)
10. Describe muscle blood flow and cardiac output during exercise (MP)
11. Describe circulatory shock and physiology of its treatment (MP)

UNIT 4: THE NERVOUS SYSTEM & SYNAPSES

- General design of the nervous system
 - Major levels of the central nervous system
 - Types of synapses, chemical and electrical
 - Physiological anatomy of the synapse
1. Describe the basic functional unit of the nervous system (MP)
 2. Describe the sensory and motor parts of the nervous system (MP)
 3. Explain the “integrative” function of the nervous system (MP)
 4. Explain how information is stored in memory (MP)
 5. Describe the three major levels of the central nervous system and understand their functional characteristics (MP)
 6. Describe the two major types of synapses and explain how they differ (MP)
 7. Describe the “principle of one-way conduction” and why is it important (MP)
 8. Describe a typical anterior motor neuron and list the functions of its 3 major parts (MP)
 9. Describe the form and function of presynaptic terminals and how they interface with postsynaptic terminals (MP)
 10. Describe the mechanism by which an action potential causes transmitter release from the presynaptic terminals and what ions are involved (MP)
 11. Explain the action of the transmitter substance when it reaches the postsynaptic neuron (MP)
 12. List the two types of ion channels in the postsynaptic neuronal membrane and know how they differ (MP)
 13. Explain the “second messenger” systems in postsynaptic neurons (MP)
 14. Describe electrical events during neuronal excitation and inhibition (MP)
 15. Describe spatial summation and temporal summation in neurons (MP)
 16. Describe the following special characteristics of synaptic transmission: fatigue, acidosis/alkalosis, hypoxia, drugs (MP)

UNIT 5: THE EYES & VISION

- Mechanism of accommodation
- Visual acuity
- Determination of distance of an object from the eye, depth perception
- Fluid system of the eye, intraocular fluid, and pressure

- Anatomy and function of the structural elements of the retina
 - Photochemistry of vision
 - Color vision and color blindness
 - Neural function of the retina
1. Describe the bending of the lens and how different eye muscles work to change its shape (MP)
 2. Describe how the nervous system controls ciliary muscles of the eye (MP)
 3. Describe the major function of the iris (MP)
 4. Describe errors of refraction and ways used to correct these errors (MP)
 5. Describe the size of the fovea and why visual acuity substantially declines the further an image is from it (MP)
 6. Understand the clinical method for stating visual acuity (MP)
 7. Describe the 3 major means by which a person normally perceives distance (MP)
 8. State the function of intraocular fluid and describe its two portions (MP)
 9. Explain how aqueous humor is formed and how it travels through different structures of the eye (MP)
 10. List the average normal intraocular pressure and describe its range (MP)
 11. List the layers of the retina, from outside to inside (MP)
 12. Describe the major functional segments of the rods and cones (MP)
 13. Explain the blood supply of the retina (MP)
 14. Describe the light-sensitive chemicals in rod cells and cone cells (MP)
 15. Explain the role of Vitamin A in the formation of rhodopsin (MP)
 16. Describe light and dark adaptation (MP)
 17. Explain tricolor mechanisms of color adaptation (MP)
 18. Describe how white light is perceived (MP).
 19. Explain why color blindness occurs almost exclusively in males (MP)
 20. Describe the 6 different neuronal cell types in the retina (MP)
 21. Describe how transmission of most signals occur in the retinal neurons (MP)
 22. Explain the function of horizontal cells in the retina (MP)

UNIT 6: THE EARS & HEARING

- Tympanic membrane and the ossicular system
 - Cochlea, basilar membrane, and Organ of Corti
 - General acoustics terminology
 - The perception of sound
 - Sound pressure and sound power
 - Noise levels in different aerial vehicles
 - Noise regulations, measurements, and control
 - Hearing protection
1. Describe how sound is transferred from the tympanic membrane to the cochlea (MP)
 2. Explain the “attenuation reflex” and how it can reduce the decibel level of incoming sound (MP)
 3. Describe the functional anatomy of the cochlea (MP)
 4. Describe the basilar membrane and explain how the lengths and diameters of its fibers change throughout the structure (MP)
 5. Explain what is meant by a “traveling wave” regarding the transmission of sound (MP)
 6. Describe the function of the Organ of Corti (MP)

7. Discuss the function of the cerebral cortex in hearing (MP)
8. Define the terms *acoustics*, *sound* and *noise* (AM)
9. Describe how sound perceived by the human ear is measured (AM)
10. Differentiate between sound pressure and sound power (AM)
11. Describe the most common noise exposure criterion for prevention of hearing loss (AM)
12. Describe the basic instrumentation components used for sound measurements (AM)
13. Discuss the pros and cons of Hearing Protection Devices (HPDs) and how their performance is measured (AM)

UNIT 7: SKELETAL MUSCLE CONTRACTION

- Physiologic anatomy of skeletal muscle
 - General mechanisms of muscle contraction
 - Molecular mechanism of muscle contraction
 - Sources of energy for muscle contraction
 - Characteristics of whole muscle contraction
 - Transmission of impulses from nerve endings to skeletal muscle fibers
 - Muscle action potential
 - Excitation-contraction coupling
1. Describe a skeletal muscle fiber, to include the following components and their roles within skeletal muscle contraction: sarcolemma, myofibrils, actin filaments, myosin filaments, I bands, A bands, cross-bridges, Z discs, sarcomere, sarcoplasm, sarcoplasmic reticulum (MP)
 2. Describe each sequential step of the initiation and execution of skeletal muscle contraction (MP)
 3. Describe the sliding filament mechanism of skeletal muscle contraction (MP)
 4. Describe the molecular characteristics of the contractile filaments (MP)
 5. Describe the composition of actin filaments (MP)
 6. Describe the role of troponin in muscle contraction (MP)
 7. Describe the sources of energy for skeletal muscle contraction (MP)
 8. Describe the characteristics and types of whole muscle contraction (MP)
 9. Describe the transmission of impulses from nerve endings to skeletal muscle fibers (MP)
 10. Describe a muscle action potential (MP)
 11. Explain the process of excitation-contraction coupling (MP)

SECTION II – HUMAN PERFORMANCE IN EXTREME ENVIRONMENTS

UNIT 8: PHYSIOLOGICAL RESPONSE TO ACCELERATION

- Vectors and nomenclature
 - The fluid model
 - Human physiological response to acceleration forces
 - Symptoms and signs of uncompensated $+G_z$ stress
 - Human tolerance to sustained $+G_z$
 - Relative negative vertical acceleration and negative acceleration ($-G_z$)
 - The push-pull effect
 - Protection against the effects of $+G_z$
 - Potential harmful effects of sustained acceleration
1. Describe Newton's 1st, 2nd, and 3rd laws and how they relate to human acceleration in flight (AM)
 2. Define G-force (AM)
 3. Describe the vectors and nomenclature (AM)
 4. Describe the effects of force on the fluid distribution and explain the fluid model (AM)
 5. List the symptoms and signs of uncompensated $+G_z$ stress (AM)
 6. Describe the difference between A-LOC and G-LOC (AM)
 7. Describe human tolerance to sustained $+G_z$ (AM)
 8. Describe the relative negative vertical acceleration and negative acceleration ($-G_z$) (AM)
 9. Describe the "push pull" effect (AM)
 10. Describe transverse acceleration and list its effects on human physiology (G_x) (AM)
 11. Describe lateral acceleration and list its effects on human physiology (G_y) (AM)
 12. Describe multi-axis acceleration and list its effects on human physiology (AM)
 13. List the procedures that can protect against the effects of $+G_z$ and the mechanisms of these protective procedures (AM)
 14. Describe the potential harmful effects of sustained acceleration (AM)
 15. Describe G-forces that are applied to astronauts during lift off and re-entry (AM)
 16. Describe the transient acceleration and forces applied to passengers and aircraft during a crash (AM)

UNIT 9: HYPOBARIC EXPOSURE

- The atmosphere
- Gas laws
- Chronic hypoxia
- Factors influencing bubble formation and growth
- Target organs of bubbles created during decompression
- Factors thought to affect decompressive sickness
- Classification of decompression Sickness
- Decompression sickness pain and manifestations
- Hyperbaric therapy for decompression sickness
- Swallowing and the Eustachian tube
- The nose and sinus
- Oxygen loading at altitude
- Acclimatization

- Long-term adjustments to altitude
 - Metabolic, physiologic, and exercise capacities at altitude
 - Altitude training and sea level performance
 - Combined altitude stay with low altitude training
 - Acute mountain sickness and high terrestrial altitude
 - High altitude cerebral and pulmonary edema
1. Describe the composition of the earth's atmosphere (AM)
 2. Describe atmospheric pressure (AM)
 3. Define the U.S. Standard Day (pressure and temperature) (AM)
 4. Describe standard units used to measure atmospheric pressure (AM)
 5. Compute a temperature for a given altitude using the standard temperature lapse rate (AM)
 6. Define the physiological divisions/zones of the atmosphere (AM)
 7. Define the temperature divisions/zones of the atmosphere (AM)
 8. Define Boyle's Law and apply it to specific calculation examples (AM)
 9. Define Charles' Law and apply it to specific calculation examples (AM)
 10. Define Henry's Law and apply it to specific calculation examples (AM)
 11. Define Dalton's Law of Partial Pressure and apply it to specific calculation examples (AM)
 12. Describe the process involved in chronic acclimatization (AM)
 13. Describe the relationship between micro-bubble nuclei and decompression sickness [DCS] (AM)
 14. Describe how percent oxygen saturation of hemoglobin changes with increased altitude (EP; HE2)
 15. Describe the role of ventilation in response to acute hypoxic exposure with respect to alveolar concentrations of oxygen and carbon dioxide (EP; HE2)
 16. Describe the role of the carotid bodies in the ventilatory response to acute hypoxia (EP; HE2)
 17. Describe the adaptive responses that improve tolerance to acute altitude exposure (EP; HE2)
 18. Describe the effect of hyperventilation resulting from acute altitude exposure (EP; HE2)
 19. Describe the effect of acute altitude exposure on submaximal heart rate and cardiac output (EP; HE2)
 20. Describe changes in oxygen carrying capacity of blood as long-term altitude adaptation occurs (EP; HE2)
 21. Describe the changes in acid-base adjustment, plasma volume, and red cell mass in response to long-term altitude adaptation (EP; HE2)
 22. Describe the time-course for altitude acclimatization (EP; HE2)
 23. Describe the effect of increased altitude on aerobic capacity (EP; HE2)
 24. Describe the effect of altitude acclimatization on VO_{2max} upon return to sea level (EP; HE2)
 25. Describe the effect of extended altitude stay and low altitude athletic training (EP; HE2)
 26. Define Acute Mountain Sickness (AMS), High Altitude Pulmonary Edema (HAPE), and High-Altitude Cerebral Edema (HACE) (EP; HE2)
 27. Identify the symptoms of AMS (EP; HE2)
 28. Describe the prophylaxis and treatment for AMS (EP; HE2)
 29. Identify the symptoms of HAPE (EP; HE2)
 30. Describe the prophylaxis and treatment for HAPE (EP; HE2)
 31. Identify the symptoms of HACE (EP; HE2)
 32. Describe the prophylaxis and treatment for HACE (HE2)
 33. Understand the difference between supersaturation and critical supersaturation (AM)
 34. Describe what gas law has a direct influence on bubble size (AM)
 35. Describe the force that opposes bubble formation (AM)

36. Describe Haldane's Theory for DCS (AM)
37. Describe how venous gas embolism are removed from circulation (AM)
38. State the effects of atmospheric pressure on the incidence of DCS (AM)
39. Describe factors which may predispose a crewmember to DCS (AM)
40. State the prevalence of DCS pain in cases of altitude induced DCS (AM)
41. List the symptoms of the four manifestations of DCS (AM)
42. List the steps for treating DCS (AM)
43. Describe the physical and physiological benefits of hyperbaric therapy in the treatment of DCS (AM)
44. Describe the physical, anatomical, and physiological causes of an ear block (AM)
45. List the symptoms of an ear block (AM)
46. Describe the technique for the prevention of ear blocks on ascent (AM)
47. Describe the physical, anatomical, and physiological causes of a sinus block (AM)
48. List the steps for treating a sinus block (AM)

UNIT 10: VISION IN AEROSPACE

- Environment and the eye
 - Night vision goggles
 - Spatial discrimination, stereopsis, and depth perception
 - Lag in visual perception
1. Describe physiological concerns regarding a lack of oxygen to the tissues in the human eye (AM)
 2. Describe physiological concerns with the human eye under a reduction of barometric pressure (AM)
 3. Describe the visual environment as it relates to the human eye (AM)
 4. Describe the components of visibility that allow humans to see objects in their environment and acquire targets (AM)
 5. Describe night (scotopic) vision as it relates to the human eye (AM)
 6. Describe the components, and the functions of those components, of night-vision goggles (AM)
 7. Describe visual cues as they relate to the perception of depth (AM)
 8. Describe physiological concerns regarding diminished color vision in the aerospace environment (AM)
 9. Describe factors that influence a lag in visual perception while in the aerospace environment (AM)

UNIT 11: SPATIAL ORIENTATION IN FLIGHT

- Visual orientation
 - Vestibular function
 - Other sensors of motion and position
 - Spatial disorientation
 - Motion sickness
1. Define situational awareness (AM)
 2. Describe the effects of channelized attention (fascination) on situational awareness (AM)
 3. Describe the effects on performance after becoming spatially disoriented (AM)
 4. List physiological/psychological concerns specific to the Ambient Mode of visual processing (AM)
 5. Describe the anatomical components of the middle ear (AM)
 6. Describe the functional anatomy of the vestibular system (AM)

7. Describe the mechanism for sensory production of the saccule and utricle (AM)
8. Describe the mechanism for sensory function of the semicircular canals (AM)
9. Describe vestibular reflex actions (AM)
10. Describe the practical relationship between the semicircular canals and orientation (AM)
11. Describe the practical relationship between the otolith organs and orientation (AM)
12. Describe what items fall into Sherrington's self-sensing categories (AM)
13. Describe the muscle and tendon senses involved with sensation of motion and position (AM)
14. Describe cutaneous exteroceptors (AM)
15. Describe the role of auditory orientation (AM)
16. State the definition of Spatial Disorientation (AM)
17. Describe the cognitive causes of Type I (Unrecognized) disorientation (AM)
18. Describe the cognitive causes of Type II (Recognized) disorientation (AM)
19. Describe the cognitive causes of Type III (Incapacitating) disorientation (AM)
20. Describe the importance of focal dominance in preventing/recovering from spatial disorientation (AM)
21. Describe how visual dominance, vestibular suppression, and opportunism aid in maintaining spatial orientation (AM)
22. List the steps that can be taken to prevent and recover from spatial disorientation (AM)
23. State the potential disorientation factors associated with empty field myopia (AM)
24. State the potential disorientation factors associated with terrain size constancy and runway landing illusions (AM)
25. State the potential disorientation factors associated with absent focal cues (AM)
26. State the potential disorientation factors associated with absent ambient cues during black-hole and whiteout approaches (AM)
27. State the potential disorientation factors associated with autokinesis (AM)
28. State the potential disorientation factors associated with linear and angularvection illusions (AM)
29. State the potential disorientation factors associated with false horizon illusions (AM)
30. State the potential disorientation factors associated with aerial perspective illusions (AM)
31. State the potential disorientation factors associated with oculogyral illusions (AM)
32. State the potential disorientation factors associated with coriolis illusions (AM)
33. State the potential disorientation factors associated with somatogyral illusions (AM)
34. State the potential disorientation factors associated with somatogravic illusions (AM)
35. State the potential disorientation factors associated with inversion illusions (AM)
36. State the potential disorientation factors associated with G-excess effect (AM)
37. State the potential disorientation factors associated with oculogravic illusions and the leans (AM)
38. Describe the physiologic mechanisms and symptoms associated with motion sickness (AM)
39. Identify methods to prevent and treat motion sickness (AM)

UNIT 12: SPACE PHYSIOLOGY & MICROGRAVITY

- Bone loss
- Radiation hazards
- Muscle loss
- Balance, neurovestibular effects of space flight
- Cardiovascular changes
- Nutrition, maintaining body mass and preventing disease
- Motion sickness in space

1. Compare the long-term level of bone loss in microgravity to the long-term recovery of bone once an individual returns to earth's gravity (SP)
2. Describe the effects of increased carbon dioxide on bone metabolism and acid base balance (SP)
3. Describe the body's negative feedback response to a decrease in dietary calcium levels (SP)
4. List the primary factors involved in bone loss when chronically exposed to microgravity (SP)
5. Describe how microgravity affects loading of the skeleton (SP)
6. List dietary factors that influence bone metabolism (SP)
7. Describe the effects of the low light level in space on Vitamin D and calcium levels (SP)
8. Identify exercise countermeasures that could be employed during spaceflight to prevent bone loss (SP)
9. Identify the recommended diet for optimizing bone health while exposed to microgravity (SP)
10. Define ionizing radiation (SP)
11. Describe the difference between radiation with X-rays and radiation with high energy particles (SP)
12. Identify primary sources of radiation in space (SP)
13. Identify the most important factor in the ability of radiation to cause damaging biological effects (SP)
14. Define relative biologic effectiveness (SP)
15. Explain the importance of free radicals in the biological effects of radiation (SP)
16. List the long-term health effects of radiation exposure in space (SP)
17. Describe the adaptive response to radiation and how it relates to DNA repair ability (SP)
18. Describe the main radiation risks associated with long duration low earth orbit flights (SP)
19. List countermeasures for radiation hazards (SP)
20. Identify the skeletal muscles that experience the most muscle volume loss following chronic exposure to microgravity (SP)
21. Describe factors other than microgravity that contribute to muscular atrophy during space travel (SP)
22. Describe the basic principles for strength training to attenuate muscular atrophy in microgravity (SP)
23. State the main effect of space flight on the vestibular system (SP)
24. Describe the plasticity of balance control system in microgravity (SP)
25. Describe the effects of weightlessness on an astronaut's ability to sense lateral acceleration and roll after returning to earth's gravitational field (SP)
26. Describe how vestibular ocular reflexes are affected by a gravitational field after the vestibular system has adapted to weightlessness (SP)
27. Describe the challenges associated with walking, running, and egress in a gravitational field after adaptation to weightlessness (SP)
28. Describe the effects of the initial fluid shift due to weightlessness on stroke volume and heart size (SP)
29. Explain the reason for the cardiac atrophy experienced by astronauts during extended space flight missions (SP)
30. Describe the effects of weightlessness on plasma volume, hematocrit, and erythropoietin (SP)
31. Describe the effects of returning to a gravitational field after 9 – 14 days of weightlessness on maximal oxygen uptake, peak stroke volume, and cardiac output (SP)
32. State the most likely contributor to the orthostatic intolerance experienced by those who have adapted to weightlessness and return to a gravitational field (SP)
33. Describe lower body negative pressure and how it can be used as an orthostatic intolerance countermeasure during space flight (SP)
34. Describe the most plausible motion sickness theory that encompasses almost all forms of motion sickness (SP)
35. List the symptoms of motion sickness (SP)
36. Describe space sickness and its possible operational impact on a space mission (SP)

37. Compare the performance effects of motion sickness tasks requiring sustained attention and tasks that can be characterized as emergencies (SP)
38. Describe the effect of anticholinergics on motion sickness (SP)
39. Describe P6 pressure on motion sickness (SP)
40. Identify the time course of space motion sickness (SP)
41. Describe the effectiveness of using pre-space flight adaptation training in the prevention of space motion sickness (SP)
42. List the side effects of scopolamine (SP)
43. Explain how scopolamine may interfere with the habituation to a sensory conflicting environment (SP)
44. Identify drugs used to treat motion sickness (SP)

UNIT 13: HYPERBARIC EXPOSURE

- Pathophysiological effects of pressure, barotrauma
 - Pathophysiological effects of common diving gas mixtures
 - Decompression sickness
1. Describe how Boyle's Law, Henry's Law, and Dalton's Law are related to barotrauma and decompression sickness (HE2)
 2. Describe physiological concerns associated with the middle ear, sinuses, lungs, and brain associated with diving (HE2)
 3. Describe physiological concerns associated with pulmonary oxygen toxicity (HE2)
 4. Describe physiological concerns associated with cerebral oxygen toxicity (HE2)
 5. Describe physiological concerns associated with carbon dioxide and carbon monoxide toxicity (HE2)
 6. Describe the physiological concerns of nitrogen narcosis, helium, and other inert gasses (HE2)
 7. Describe the physiological concerns associated with decompression sickness (HE2)
 8. Describe the physiological concerns associated with flying after diving and diving at altitude (HE2)
 9. Describe the factors affecting individual susceptibility associated with decompression sickness (HE2)
 10. Describe the differences in occurrence, causation, and symptomology associated with decompression sickness and cerebral arterial gas embolism (HE2)
 11. Describe the treatment of decompression sickness and arterial gas embolism (HE2)

UNIT 14: THERMOREGULATION IN HOT & COLD ENVIRONMENTS

- Thermal balance
 - Hypothalamic temperature regulation
 - Thermoregulation in cold stress, heat conservation and heat production
 - Thermoregulation in heat stress, heat loss
 - Effects of clothing on thermoregulation
 - Physical activity in the heat
 - Factors that modify heat tolerance
 - Complications from excessive heat stress
 - Thermoregulation and environmental cold stress during physical activity
 - Cold water immersion
1. Explain how the hypothalamus maintains thermal balance (EP)
 2. Explain the four physical factors that contribute to heat gain and loss (EP)
 3. Explain the impact of humidity in evaporative heat loss (EP)

4. Describe the integration of heat dissipating mechanisms (EP)
5. Define Clo (EP)
6. List factors that affect the insulation value of clothing (EP)
7. Discuss factors that regulate cutaneous and muscle blood flow during exertion in the heat (EP)
8. Discuss factors that regulate blood pressure during exertion in the heat (EP)
9. Describe the consequences of dehydration on physiology and performance (EP)
10. Describe the purpose of fluid replacement and proposed benefits of pre-exercise hyperhydration (EP)
11. Describe the purpose of glycerol supplementation during physical activity in a hot environment (EP)
12. Describe the volume and electrolyte characteristics of a rehydration beverage to restore water and electrolyte balance following prolonged effort in heat (EP)
13. Explain how acclimatization modifies heat tolerance during physical activity (EP)
14. Explain how training modifies heat tolerance during physical activity (EP)
15. Explain how gender modifies heat tolerance during physical activity (EP)
16. Explain how body fat level modifies heat tolerance during physical activity (EP)
17. Discuss the immediate and possible long-term physiological adjustments to cold stress (EP)
18. Compare the difference in heat lost between cold-water immersion and cold air exposure (HE1)
19. State the type of heat exchange that is responsible for nearly all heat loss associated with cold-water immersion (HE1)
20. Compare the heat dissipation capacity of air and water (HE1)
21. State the most life-threatening effect that occurs during the initial entry into cold water (HE1)
22. List the factors that determine the rate at which core body temperature falls when submerged in cold water (HE1)
23. Describe initial and long-term (minutes to hours) effects of cold-water immersion on the heart (HE1)
24. Describe the initial and long-term effects of cold-water immersion on vascular response (HE1)

SECTION III – HUMAN PERFORMANCE OPTIMIZATION

UNIT 15: HYDRATION

- Water intake and electrolyte balance
 - Thirst and satiation
 - Physiological consequences of body water imbalance
 - Factors influencing daily water requirements
 - Impact of hot environments on fluid requirements
 - Effect of cold weather operations on water requirements
 - Effect of high-altitude operations on water requirements
 - Effect of water immersion on water requirements
 - Barriers to rehydration
 - Strategies to sustain hydration in harsh environments
1. Describe how body water is distributed among 3 principal fluid compartments (WR)
 2. Identify adequate total water intake (liters/day) for men and women > 19 years old (WR)
 3. Explain the effects of sweat induced dehydration on volume and osmotic pressure of plasma (WR)
 4. Describe how plasma hyperosmolarity occurs and how it affects plasma volume during times of dehydration (WR)
 5. Explain the roll of osmoreceptors and how they are involved in regulation of renal water reabsorption and thirst (WR)
 6. Explain the importance of oral sensations on the desire to drink (WR)
 7. Identify the percent loss of body weight associated with the first sensation of thirst (WR)
 8. Identify the percent loss of body weight associated with signs if apathy, fatigue, and nausea (WR)
 9. Describe effects of dehydration on thermal strain of exercise in temperate and hot environments (WR)
 10. Explain how dehydration exerts its effects on thermoregulation (WR)
 11. Explain how dehydration affects the cardiovascular response to submaximal and maximal aerobic exercise in hot environments (WR)
 12. Describe the effects of dehydration on core temperature during exercise in hot environments. (WR)
 13. Define hyponatremia (WR)
 14. Describe how sweat rate, air temperature, and physical activity duration affect hyponatremia risk (WR)
 15. Explain methods to prevent or reduce the risk of hyponatremia (WR)
 16. List the factors that influence daily water requirements (WR)
 17. Identify general water requirements for moderate intensity work in temperate, hot environments, and extremely hot environments (WR)
 18. Explain cold-induced diuresis (WR)
 19. Describe factors associated with cold environments that could increase daily fluid requirements (WR)
 20. Explain the effects of the first 1-3 days of high-altitude operations on water balance in the unacclimatized (WR)
 21. Explain why the initial fluid loss at high altitudes can be beneficial (WR)
 22. Identify strategies to sustain hydration in harsh environments (WR)

UNIT 16: HUMAN FACTORS

- Human factors in aerospace systems and operations
- Fatigue in aviation and space settings
- Human error

- Anthropometry
 - Design and operations
 - Crew resource management
 - Human factors in manned versus unmanned aviation
 - Human factors objectives and components
1. Define common human performance characteristics relevant to the understanding of human factors in aerospace systems and operational procedures (AM)
 2. Describe fatigue as it relates to aviation settings (AM)
 3. Describe fatigue as it relates to space operations (AM)
 4. Describe human error as it related to aerospace operations (AM)
 5. Define the themes around which human error has historically contributed to aviation accidents (AM)
 6. Define cross-cutting factors that contribute to human error vulnerability (AM)
 7. Explain the importance of an operational requirement with regards to anthropometry (AM)
 8. Describe the task of cockpit mapping as it related to anthropometry (AM)
 9. Describe a user interface as a design consideration in human factors (AM)
 10. Explain the concept of Crew Resource Management (CRM; AM)
 11. Describe some pertinent differences in human factors concerns for unmanned versus manned aviation (AM)
 12. Describe the overall key objectives and key components of human factors (AM)

UNIT 17: MEMORY, SLEEP, & FATIGUE

- Memory traces
 - Memory formation
 - Classifications of memory
 - Definitions of and subdivisions of memory
 - Structural changes in synapses and role of hippocampus in memory formation
 - Slow wave sleep and REM sleep
 - Normal EEG brain waves during various phases of sleep
 - Quantification and effects of fatigue
 - Factors affecting alertness
 - Sleep deprivation and effects on cognition
 - Circadian rhythms and desynchronization
 - Effects of jet lag and shift lag on circadian rhythms
 - Different types of sleep, sleep stages, and sleep architecture
 - Indicators of increased fatigue risk
 - Sleep habits
 - Fatigue countermeasures, anti-fatigue strategies and caffeine use
1. Define memory traces (MP)
 2. Describe the role of sensitization and habituation of synaptic sensitization in the formation of memories (MP)
 3. Explain the different classifications of memory (MP)
 4. Define working memory (MP)
 5. Describe the subdivisions of working memory (MP)

6. Describe the structural changes that occur in synapses during development of long-term memory (MP)
7. Describe the process of consolidation of memory (MP)
8. Explain the role of the hippocampus in memory formation (MP)
9. Describe slow wave sleep (MP)
10. Describe Rapid Eye Movement (REM) sleep (MP)
11. Name the different types of brain waves in a normal electroencephalogram (EEG; MP)
12. Describe the progressive change in the characteristics of the brain waves during different stages of wakefulness and sleep (MP)
13. Define fatigue (FA)
14. Describe how fatigue is quantified (FA)
15. Describe the typical effects of fatigue (FA)
16. Describe the three primary factors that affect alertness (FA)
17. Explain how sleep deprivation interacts with time of day and cognitive performance (FA)
18. Describe the suprachiasmatic nucleus and its role in circadian rhythms (FA)
19. Describe circadian desynchronization (FA)
20. Describe jet lag and its effects on circadian rhythms (FA)
21. Describe shift lag and its effects on circadian rhythms (FA)
22. Describe the process of sleep through physiological recordings (FA)
23. Classify the different types of sleep (FA)
24. Compare Non-REM and REM sleep (FA)
25. Describe the distribution of sleep stages throughout a night's sleep (FA)
26. Describe the modifiers of sleep architecture (FA)
27. Describe how chronic sleep restriction affects performance (FA)
28. List indicators of increased fatigue risk (FA)
29. Describe sleep habits that lead to better sleep (FA)
30. Describe fatigue countermeasure strategies for shift workers (FA)
31. Describe adaptation strategies for shift and jet lag (FA)
32. Describe non-pharmaceutical anti-fatigue strategies for situations involving sleep restriction (FA)
33. Describe how caffeine can be used as an anti-fatigue mitigation strategy (FA)

UNIT 18: NUTRITION

- Carbohydrates
 - Gluconeogenesis, glycogen, glycogenesis, and glycogenolysis
 - Lipids
 - Proteins and amino acids
 - Metabolism
 - Nutrient intake among the physically active
 - Physical activity and food intake
 - Carbohydrate feedings prior to, during, and recovery from physical activity
1. List the major types and sources of carbohydrates (EP)
 2. Discuss the physiological significance of gluconeogenesis (EP)
 3. Discuss the physiological significance of glycogen (EP)
 4. Discuss the physiological significance of glycogenesis (EP)
 5. Discuss the physiological significance of glycogenolysis (EP)
 6. Describe the role of carbohydrates in the human body (EP)

7. Identify the general daily recommendations for carbohydrate intake for sedentary and physically active individuals (EP)
8. Discuss the dynamics of carbohydrate metabolism during physical activity (EP)
9. List the major types and sources of lipids (EP)
10. Provide daily recommendations for lipid intake for sedentary and physically active individuals (EP)
11. Discuss the role of lipids in the body (EP)
12. Discuss the dynamics of lipid metabolism during physical activity (EP)
13. Describe the effects of exercise training on fat metabolism (EP)
14. Compare essential and non-essential amino acids (EP)
15. List examples of protein sources (EP)
16. Discuss recommended protein intake for sedentary and physically active individuals (EP)
17. Discuss the role of protein in the body (EP)
18. Discuss protein dynamics during physical activity (EP)
19. Discuss macronutrient intake among the physically active (EP)
20. Compare high fat versus low fat diets for exercise training and performance (EP)
21. Discuss carbohydrate feedings prior to, during, and recovery from physical activity (EP)

SECTION IV – AEROSPACE MEDICINE AND HUMAN PERFORMANCE LITERATURE

UNIT 19: AEROSPACE MEDICINE AND HUMAN PERFORMANCE JOURNAL ARTICLES, 2017 – 2023

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12. Leinonen AM, Varis NO, Kokki HJ, Leino TK. *Normobaric hypoxia symptom recognition in three training sessions*. *Aerosp Med Hum Perform*. 2024; 95(10):758-764.