CAA Private Pilot's License (A) Reference Memorandums

Memo 3: Human Performance and Limitations

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Contents

1. Relevant Sayings

- To err is human
- There is no reason to fly through a thunderstorm in peacetime
- Learn from the mistakes of others - you won't have time to make them all yourself
- If you feel "iffy" on the ground, it only gets much worse in the air!
- It's better to be down here wishing you were up there, than up there wishing you were down here!
- Aviate, Navigate, Communicate
- Never let an aircraft take you where your brain didn't get to 5 minutes earlier.
- There's simply no substitute for experience in terms of aviation safety. (Chesley Sullenberger)

2. Introduction

- Generally, most accidents are down to human error
- The key factor in these situations is where the ability of the pilot to remain alert is degraded (for example after a long flight) and the workload begins to rise

3. Basic Anatomy

- The body is made up of many sub-"systems"
- Aviation is primarily interested in: vision, hearing, the vestibular system and and human condition (mind)
- We are build to walk and run, not fly!
- Everyone is different and will react differently to different situations, however general rules can be determined

4. Health and Flying

- Remember IMSAFE
- After anaesthetic, the recommended wait times are:
  - Local: wait 12 hours
  - General: wait 48 hours
- Alcohol limits:
  - Breath: 9µg/100ml
  - Blood: 20mg/100ml
  - Urine: 27mg/100ml
  - After two units, error ratios double
- Arousal and performance
  - Arousal, in this situation, is a measure of alertness
  - High arousal does not mean best performance, e.g. fixation
- Consider passengers
  - Airsickness:
    - keep feet flat on the floor

  - look at the distant horizon
  - keep seat belt secured firmly
  - keep hydrated
  - maintain comfortable but not excessive cabin heat

5. Atmospheric Environment

- The atmosphere is thin!
- Most aviating is performed in the troposphere, where weather is!
- Some aviating is in the stratosphere, above weather.
- The atmosphere is 78% N, 21% O_2, 1% other
- Gas laws:
  - Boyle's Law: $PV = k_1$ ($k_1 = nRT$)
  - Charles' Law: $V = k_2 T$
  - Dalton's Law: $P_{\text{total}} = P_1 + P_2 + P_3 + ... + P_n$
  - Henry's Law: $p(\text{partial pressure}) = k_{\text{hc}}$ (the amount of gas dissolved in a liquid is proportional to the gas pressure outside the liquid)
- Atmospheric pressure decreases with altitude, but the gas composition remains constant.

6. Respiration

- Normal resp rate: 12-15
- Resp rate is dictated by the amount of CO_2 in blood
- Alveoli are dependent on partial pressure
- At increasing altitude:
  - We are less able to perform gas exchange due to reduced partial pressures
  - There is less pressure of air, which also reduces lung pressure overall
- Hypoxia
  - Symptoms:
    - Lethargy/Eurphoria
    - Personality change
    - Increased resp rate
    - Poor co-ordination
    - Poor judgement
    - Dizziness
    - Headache
    - Memory loss
    - Concentration difficulties
    - Slurred speech
    - Nausea
    - Tingling in hands and feet
    - Sweating
    - Irritability

    - Ear/stomach discomfort
    - Visual impairment
    - Cyanosis
  - At altitudes:
    - FL200: 5-12m
    - FL250: 2-3m
    - FL300: 45-75s
    - FL350: 30-45s
    - FL400: 18-30s
  - Those with the following are at increased risk:
    - Asthma
    - Lungs that have undergone surgery
    - Smokers

- Hyperventilation
  - Caused by:
    - stress
    - anxiety
    - continuous vibration
    - high G
    - pain
    - motion sickness
    - heat
  - Same symptoms as hypoxia

- Decompression Sickness
  - Caused by:
    - Explosive decompression above FL180
    - Normal decompression due to climb in those susceptable:
      - Altitude and length of stay
      - Unfitness
      - Increased age
      - Re-exposure following previous DCS
      - Low temperatures and hypoxia
      - Scuba diving
  - Symptoms:
    - Gas expansion
    - Bends (joint pain)
    - Creeps (bubbles under skin)
    - Chokes (PE system bubbles)
    - Shortness of breath
    - Dizziness
    - Fatigue
    - Paralysis
    - Death
  - Can only be treated in a hyperbaric chamber
  - Recommendations for divers:
    - If diving less than 10m, allow 12 hours before any flight
    - If diving more than 10m, allow 24 hours before any flight

7. Circulation

- Normal HR: 60-80
- Positive G
  - G-LOC
  - Grey out
  - Tunnel vision
  - Black out
- Negative G
  - Red out
- Untrained G tolerance
  - $< 4G$, $< 2s$ okay
  - sustained >3G, gradual symptom onset
  - sudden high G, G-LOC
- A shorter distance from head to heart increases G tolerance
- G-suits
  - Give an extra 2G protection
  - Connected to A/C air pressure systems
- Anti-G straining manoeuvre
  - Isometric straining of legs, buttocks and arm muscles to prevent pooling
  - Power breathing to continue breathing during the straining
- Regular G exposure increases tolerance

8. Vision

- Rods detect motion better
- The fovea has a higher concentration of cones
  - Look around – an A/C approaching you directly on would be harder to spot otherwise
- Night vision
  - Cones are useless
  - Rods take 30-40 minutes in dim light to fully switch
  - A bright light for 5 seconds will need another 30-40 minutes
  - Look to the one side (by 10°) for better clarity
- On a hazy day, objects are closer than we think (because we can't see as far but think we can)
- On a rainy day, the rain on the windshield refracts light such that the pilot thinks they are higher than they are.
- At night, lit objects appear closer than they are (including the lit runway)

9. Hearing

- Frequencies below 100Hz cause the body to sweat

10. Vestibular System

- Trust the instruments over your own ear!

10.1. Illusions

- The Leans
  - A slow bank angle change isn't detected by the ear
  - A slow change, followed by a rapid correction, can fool your brain into thinking you are still banked when you are in fact wings level
- Sloping Cloud
  - Where two cloud layers meet at a slope, a horizon can be (wrongly) perceived at an angle
- Yaw and Bank
  - If an in-balance turn is held for a while, this becomes "straight and level" to the ear
  - In a flat turn, the ear thinks there is bank present

11. Nervous System

- Autonomic: unconscious actions
- Central: co-ordination
- Peripheral nerves: connects to limbs and organs

12. Psychology

- Short term memory:
  - images for $\frac{1}{2}$ second
  - sounds for 3 to 8 seconds
  - very volatile, 7 items
- Long term memory:
  - may not be able to be recalled at will
  - more difficult to recall if not practiced (abnormal procedures)
- Decision making:
  - cognotive biases
    - availability bias: accept the easiest to understand and implement decision
    - familiarity bias: previous outcomes affect our decision
    - confirmation bias: once a decision is made, it's easier to confirm that decision than challenge it
    - continuation bias: never change the first answer

  - CRM: express doubts, raise questions without being confrontational
- Communication:
  - written: slow and easily misinterpreted
  - verbal: accents can be challenging
  - non-verbal
- Concentration:
  - attention
  - divided attention

13. Ergonomics

- Know your aircraft!

14. Threat & Error Management

- Only one factor of an accident needs to be prevented to prevent the accident itself
- Procedures help reduce risk
- Personal improvement
  - Without improvement, complacancy surfaces
- Personal currency
  - Skill fade is real!
- Identify threads and errors before flight so they can be managed
  - environmental threats
  - operational threats
  - handling errors
  - procedural errors
  - communication errors

15. First Aid

- Remember DRcABCDE