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CPL · ATPL · Human Performance & Limitations Aviation Physiology & Human Factors

Part 1 of the master study set — Atmosphere · Gas Laws · International Standard Atmosphere · Pressure–Altitude Effects · Physiological Zones of the Atmosphere

CHAPTER

Chapter 26 (the DGCA reference textbook)

INSTRUCTOR

Ghost Aviator

EXAM

DGCA CPL / ATPL — HPL

Why this chapter matters to a pilot

Aviation Physiology deals with the **physical and mental effects of flight on aircrew personnel and passengers**. In aviation, the demands upon the compensatory mechanisms of the body are *numerous and of considerable magnitude*. The environmental changes of greatest physiological significance involved in flight are:



- Marked changes in **barometric pressure**
- Considerable variation in **temperature**
- **Movement at high speed in three dimensions**

This part of the syllabus familiarises you with the physiological problems of flight and assists in human compensation for the numerous environmental changes encountered in flight. **Remember: every human is physiologically different and can react differently in any given situation.**

Contents – Part 1

1. The Atmosphere & its Constituent Gases
2. The Gas Laws (Boyle · Henry · Charles · Graham · Dalton)
3. Variation of Pressure & Temperature with Altitude (ISA)
4. Partial Pressure of Oxygen at Increasing Altitudes
5. The Physiological Zones of the Atmosphere
6. Self-Check & Memory Aids

§ 1

The Atmosphere

Human beings live their lives in the **lower reaches of the atmosphere** where temperatures, pressures and oxygen supply are able to support life. The moment we climb, every one of those three variables shifts against us. To fly safely, you must first understand the layer you're flying in and what it is made of.

1.1 The Layers — Troposphere & Stratosphere

TROPOSPHERE – AVERAGE TOP

13 km • 8.1 mi •
43,000 ft

STRATOSPHERE – REACHES
ABOVE

100,000 ft

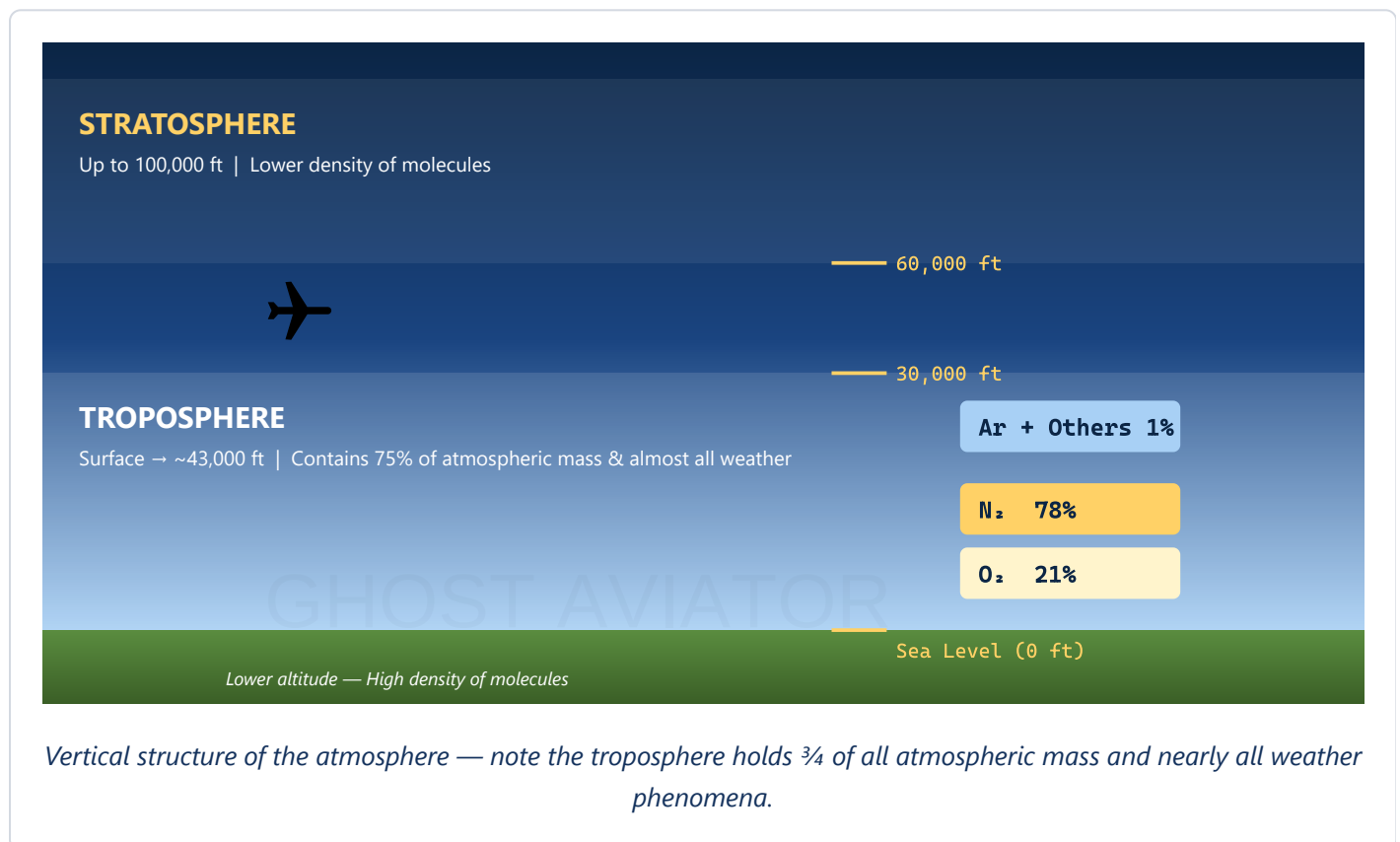
WHERE ALMOST ALL WEATHER
LIVES

Troposphere

WHERE AIR IS DENSEST

**Lowest Layer
(Surface)**

The Troposphere height **varies**. On average it stretches from the Earth's surface to about **13 km (8.1 mi; 43,000 ft)**. The Stratosphere reaches up to over **100,000 ft**. The troposphere contains **almost all the weather**, the air is densest in this lowest layer, and in fact the troposphere contains **three-quarters of the mass of the entire atmosphere**.



1.2 Constituent Gases of the Atmosphere

The earth's atmosphere near the surface is composed primarily of **Nitrogen** and **Oxygen**. Together, the two comprise **about 99%** of the gas in the atmosphere. The remaining 1% is made up of Argon plus traces of other gases.

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Composition of the lower atmosphere — exact percentages

Gas	Percentage	Gas	Percentage
Nitrogen (N ₂)	78.084 %	Oxygen (O ₂)	20.95 %
Argon (Ar)	0.934 %	Carbon Dioxide (CO ₂)	0.036 %
Neon (Ne)	0.0018 %	Helium (He)	0.0005 %
Methane (CH ₄)	0.00017 %	Hydrogen (H ₂)	0.00005 %
Nitrous Oxide (N ₂ O)	0.00003 %	Ozone (O ₃)	0.000004 %

In addition, **water vapour** is variable but typically makes up about **1 – 4 %** of the atmosphere.

Critical principle to remember



The relative proportions of these gases remain CONSTANT in the Troposphere and Stratosphere. What changes with altitude is not the *percentage* of oxygen — it is the *total pressure*, and therefore the **partial pressure** of each gas. Oxygen continues to make up 21 % of the air by volume **at every altitude**; only the partial pressure of oxygen, pO_2 , falls.

MNEMONIC

"Never Ought An Cool Naval Helmsman Make His Nasty Owl" — Nitrogen, Oxygen, Argon, Carbon dioxide, Neon, Helium, Methane, Hydrogen, Nitrous oxide, Ozone — in descending order of abundance. (Optional aid — feel free to invent your own.)

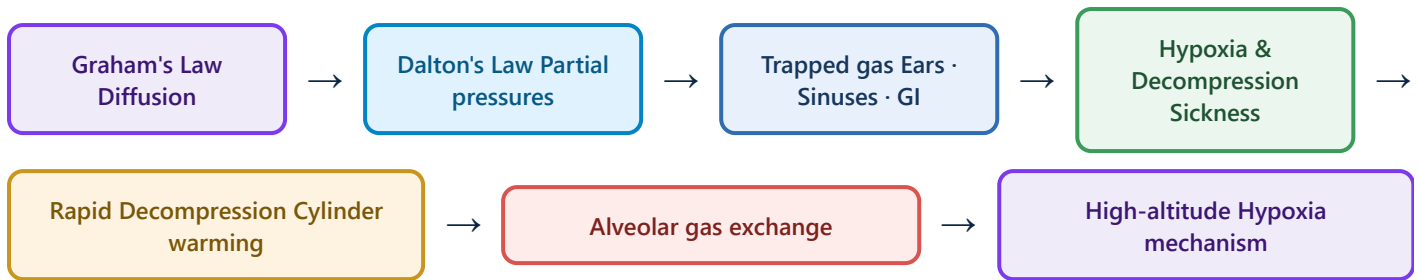
§ 2

The Gas Laws

The body responds to barometric pressure changes in temperature, pressure, and volume. These changes are **rapid and continuous** in the aviation environment. It is therefore essential to know the implication of these changes on our body and take preventive measures to counter them. The gas laws explain to us the **science behind what goes on within our body** when exposed to changes in pressure and temperature.



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2.1 Boyle's Law

Definition



At a **constant temperature**, a given volume of gas is **inversely proportional to the pressure** surrounding the gas. The volume of gas **expands as the pressure surrounding the gas is reduced**.

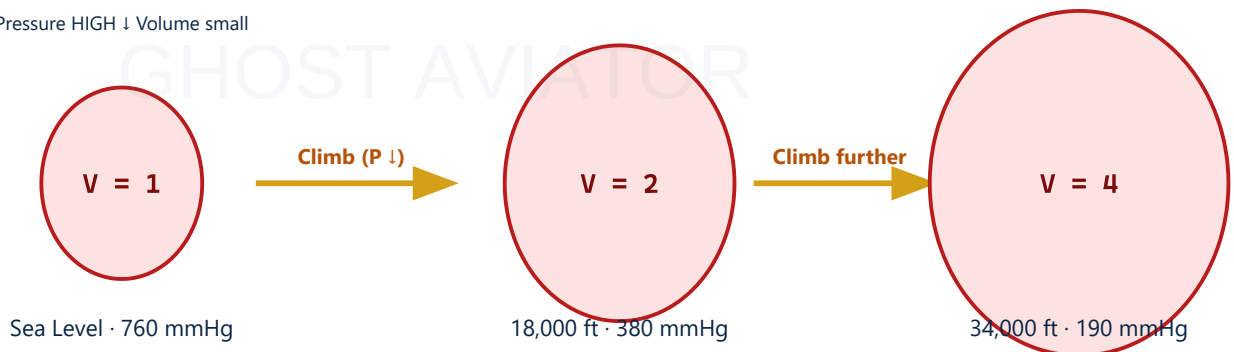
- **As altitude increases** → **gas expands**.
- **As altitude decreases** → **gas compresses**.
- The amount of volume expansion is **limited by the pliability** of the structure or membrane which encloses the gas.

Examples in aviation & medicine



PASG / Air Splints · Respiratory Rate & Depth changes · Flow rates of **IV sets** · **ETT** or **Tracheal cuff** pressures · **Trapped gas effects** within the body (middle ear, sinuses, GI tract — every pilot has felt these).

Pressure HIGH ↓ Volume small



*Boyle's Law: as pressure halves, a fixed mass of gas **doubles** in volume. Trapped gas in your sinus, ears, gut and tooth-fillings literally tries to expand as you climb.*

2.2 Henry's Law

Definition



The amount of **gas in solution** is proportional to the **partial pressure of that gas over the solution**. As the pressure of the gas above a solution *increases*, the amount of that gas dissolved in the solution *increases*; the reverse is also true — as the pressure of the gas above a solution *decreases*, the amount of gas dissolved *decreases* and forms a **"bubble" of gas within the solution**.

In normal physiologic function, this law can be seen in the **transfer of gas between the alveoli and the blood**. This is **significant physiologically** for the occurrence of evolved gas disorders, e.g. **decompression sickness**. It explains the hypoxia experienced with increasing altitude — as the pressure of gases is reduced with ascent, the amount of gases dissolved in solution decreases, and this leads to hypoxia and may lead to **nitrogen bubble formation**.

Everyday example



Bottle of soda. With the cap on, the gas within the solution is at equilibrium. With the cap removed, the gas pressure decreases and bubbles are released into the solution. Your blood does exactly the same thing on a sudden cabin depressurisation.

Clinical link — DCS (decompression sickness)



A pilot who has been SCUBA diving cannot climb shortly after surfacing because Henry's Law is still working against them — dissolved nitrogen in their blood will come out of solution as bubbles when ambient pressure falls. (*Strict wait-times before flying after diving are covered in a later section.*)

2.3 Charles' Law

Definition



The **pressure of a gas is directly proportional to its temperature** with the **volume remaining constant**. Temperature increases make gas molecules move faster, greater force is exerted, and volume expands.

The law explains:

- The **temperature changes associated with rapid decompression**.

- The **pressure changes that induce temperature changes with an oxygen cylinder** (a freshly-charged O₂ bottle feels warm; a discharging one feels cold).

Classic illustration



Shaving cream can be placed into a fire — heat raises the internal pressure of the can until the structure fails. Same physics governs the rapid heating of an oxygen cylinder during fast filling.

2.4 Graham's Law — Law of Gaseous Diffusion

Definition



Gases **diffuse or migrate from a region of higher concentration (or pressure) to a region of lower concentration (or pressure)** until equilibrium is reached. The physiological significance is in the explanation of **gas exchange**.

SOP — How your lungs use this law



Oxygen moves from the alveoli into the blood, and from the blood into the tissues due to this phenomenon. The whole architecture of the respiratory system relies on Graham's Law for survival.

2.5 Dalton's Law — Law of Partial Pressures

Definition



Partial pressures describe the **distribution of certain gases in a mixture** and follows Dalton's law which states that the **total pressure of a mixture of gases is equal to the sum of the partial pressures of the gases which compose the mixture**. As altitude increases — gases exert **less pressure**. This explains the **hypoxia that occurs with flight to higher altitudes**.

Worked example — Oxygen at different altitudes (Dalton's Law in action)

At Sea Level: $O_2 = 21\%$ & $pO_2 = 21\% \times 760 \text{ mm} = \approx 160 \text{ mmHg}$

At 8,000 ft: $O_2 = 21\%$ & $pO_2 = 21\% \times 565 \text{ mm} = \approx 119 \text{ mmHg}$



The barometric pressure at **36,000 ft** is **one-fourth** of that at sea level. Hence the quantity of oxygen available is **proportionately low**. *Whatever the air pressure, oxygen continues to make up 21 % of the air by volume.* In other words, the **proportion of oxygen in the air always stays the same whatever the altitude**. The **partial pressure of Oxygen decreases with altitude as does the total pressure of air**.

Exam-critical takeaway



The percentage of O_2 in air does **NOT** change with altitude — it is always **21 %**. What kills the pilot is the falling **partial pressure** of that oxygen, because diffusion across the alveolar membrane depends on *pressure gradient*, not percentage.

Quick-Reference — The Five Gas Laws of Aviation Physiology

Law	One-line Statement	What it Explains in Flight
Boyle's	$P \times V = \text{constant}$ (at fixed T) — pressure $\uparrow \rightarrow$ volume $\downarrow$	Trapped-gas pain in ears, sinuses, teeth, GI tract; tracheal-cuff & IV behaviour
Henry's	Gas dissolved $\propto$ partial pressure over the solution	Decompression sickness, hypoxia mechanism, alveolar gas transfer
Charles'	$P \propto T$ (at fixed V) — warming raises pressure	Rapid-decompression temperature drop; O_2 cylinder heating
Graham's	Gases diffuse from high $\rightarrow$ low concentration	O_2 from alveoli $\rightarrow$ blood $\rightarrow$ tissues; CO_2 in opposite direction
Dalton's	Total $P = \Sigma$ partial pressures	Why high-altitude hypoxia happens despite air being "21% oxygen"

§ 3

Variation of Pressure & Temperature

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with Altitude

3.1 The International Standard Atmosphere (ISA)

What ISA actually is



The International Standard Atmosphere is used to show **standardised values for temperature, pressure, density and lapse rate**. Pressure decreases with altitude *throughout* the atmosphere. Temperature decreases with altitude *in the Troposphere*.

ISA Sea-Level Values (memorise these cold)

SEA-LEVEL PRESSURE

1013.25 hPa

EQUIVALENT (MB)

1013.25 mb

EQUIVALENT (PSI)

14.7 lb/in²

EQUIVALENT (HG)

29.92 in Hg

EQUIVALENT (MMHG)

760 mm Hg

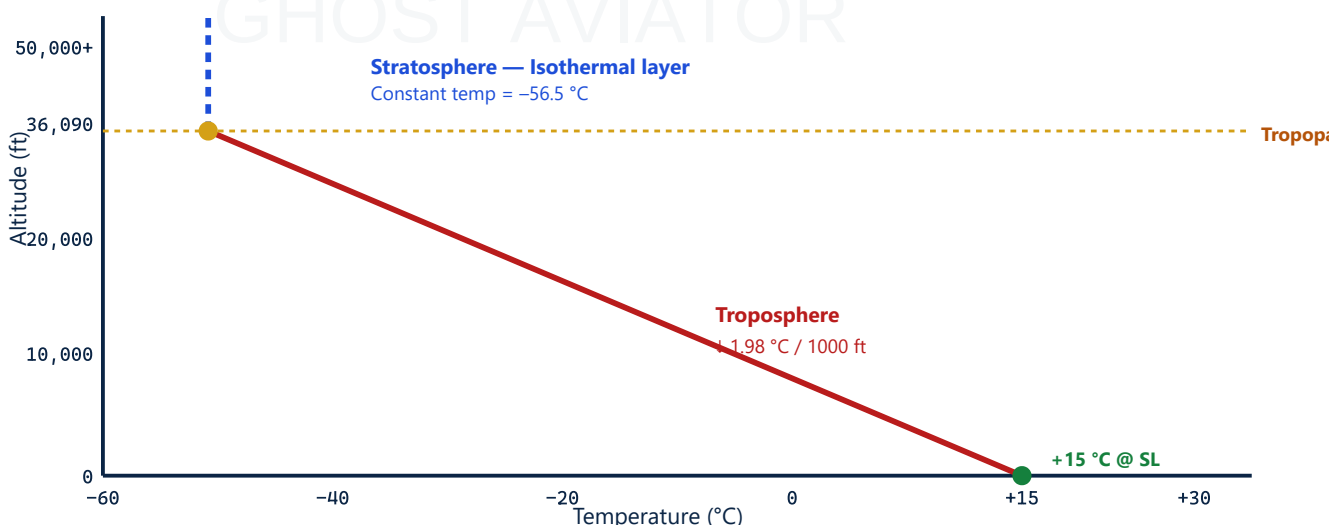
ISA LAPSE RATE

1.98 °C / 1000 ft

Strict ISA limits — examination values



Temperature reduces at **1.98 °C per 1000 ft up to 36,090 ft**. Thereafter it remains **constant** at **-56.5 °C**. (The 1.98 °C figure is the precise ISA lapse rate; many texts round to 2 °C / 1000 ft for mental maths — never round in your exam paper.)



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The ISA temperature profile: linear lapse rate of 1.98 °C / 1000 ft up to 36,090 ft, then constant at -56.5 °C through the isothermal layer of the stratosphere.

§ 4 Partial Pressure of Oxygen — Effects of Increasing Altitude

As you climb, the **total barometric pressure** drops, and with it the **partial pressure of oxygen** (pO₂). Because the diffusion of oxygen across the alveolar membrane depends on the pressure gradient, what matters to your blood is not the percentage of O₂ — it is the pO₂. Here are the standard values the DGCA expects you to know:

Standard barometric pressure & oxygen availability at altitude

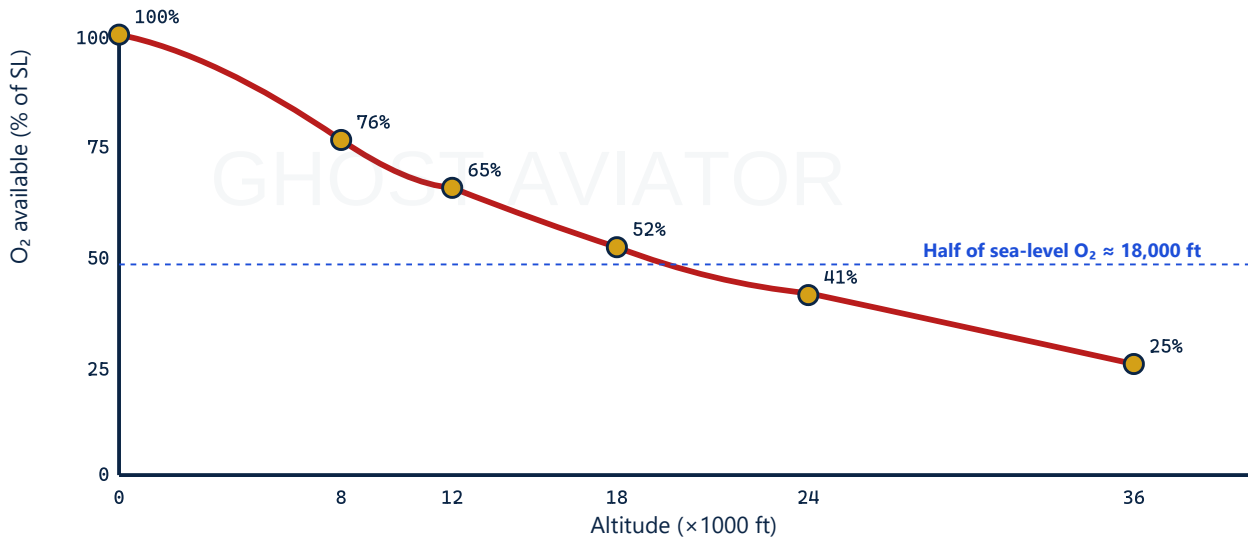
Altitude	Standard Barometric Pressure	O ₂ Available (% of Sea Level)	Pilot Significance
Sea Level (0000 ft)	101 kPa (760 mmHg)	100 %	Normal physiological baseline.
8,000 ft	77 kPa (574 mmHg)	76 %	Cabin pressure is maintained between 6,000 – 8,000 ft.
12,000 ft	66 kPa (496 mmHg)	65 %	Lower edge of the Physiological-Deficient Zone.
18,000 ft	53 kPa (395 mmHg)	52 % (≈ half)	Half the O ₂ of sea level.
24,000 ft	41 kPa (311 mmHg)	41 %	Without supplemental O ₂ — incapacitation imminent.
36,000 ft	25 kPa (187 mmHg)	25 % (one-fourth)	Only ¼ of sea-level oxygen.

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Three deductions you must be able to state in the exam



1. The **availability of oxygen and barometric pressure DECREASE** with altitude.
2. The oxygen available is **one-fourth** at **36,000 ft** and **half** at **18,000 ft** of the oxygen available at sea level.
3. **Atmospheric pressure drops faster at lower altitudes** in comparison to the same altitude changes at higher altitudes (the pressure–altitude curve is exponential, not linear).



The percentage of oxygen *available* falls non-linearly with altitude — half is gone by 18,000 ft, three-quarters by 36,000 ft.

§ 5 The Physiological Zones of the Atmosphere

The atmosphere is divided — from the pilot's body's point of view — into four functional zones, each demanding a different protective strategy. **You must know the boundaries and the SOP for each.**

Physiological Zone Sea level → 10,000 ft Air only — body copes naturally



Physiological-Deficient Zone 12,000 → 50,000 ft Body not adapted — supplementary O₂ required



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Partial Space-Equivalent Zone 50,000 ft → 120 nm 100% O₂ insufficient — pressure breathing/suit



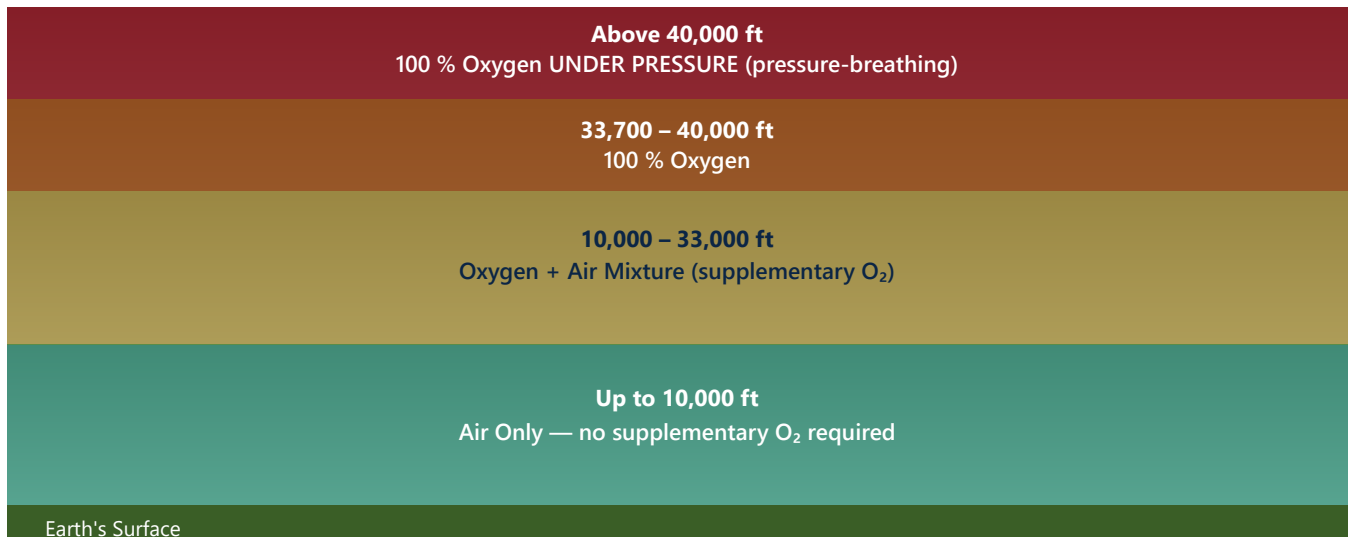
Total Space-Equivalent Zone Outwards from 120 nm Sealed cabins & pressure suits MANDATORY

5.1 The Physiological Zone

SOP — Within this zone



Normal healthy human beings used to living near sea level will need **supplementary oxygen to function normally at altitude exceeding 10,000 to 12,000 ft**. Pilots will normally begin breathing supplementary oxygen from **10,000 ft** above sea level.



Oxygen-supply regime by altitude — the four pressure-breathing/oxygen zones every pilot must know.

5.2 The Physiological-Deficient Zone

Limits & symptoms — strict

Exists from **12,000 ft to 50,000 ft**. **The body is not used to this environment.** The adverse effects include:



- Middle ear and sinus blockage
- Shortness of breath
- Dizziness
- Headache

Compensatory threshold



At **6,000 – 7,000 ft** altitude the human organism starts with remarkable measures to compensate for the drop in pO_2 when climbing — this is the **threshold for compensatory reactions**. (Hyperventilation, raised heart rate, raised cardiac output, etc. — all later sections.)

Critical-threshold limits — non-pressurised flight



- A pilot climbing in a **non-pressurised aircraft and WITHOUT using supplemental oxygen** will pass the "**critical threshold**" at approximately **22,000 ft**.
- **Breathing 100 % oxygen** will lift the pilot's physiological safe altitude to approximately **38,000 ft**.

5.3 The Partial Space-Equivalent Zone

Definition & extent



This zone extends from **50,000 ft to 120 nm** (nautical miles). Even 100 % oxygen ceases to be enough at these heights — total pressure becomes the limiting factor.

5.4 The Total Space-Equivalent Zone

Definition



The Total Space-Equivalent Zone extends **outwards from 120 nm**.

Mandatory limits in the upper two zones



- **100 % oxygen does NOT protect from hypoxia** — pressure-breathing required.
- **Sealed cabins and pressure suits are a MUST.**
- Blood and body fluids **BOIL above 63,000 ft** (Armstrong's Line — vapour pressure of body fluids equals ambient pressure).
- **Gravitational changes affect the body** (micro-G adaptation, fluid shift, motion-sickness, etc.).

Altitude-vs-Pilot Protection Timeline

Up to 10,000 ft	Air only — no O ₂ needed
10,000 – 33,000 ft	Oxygen + Air mixture
33,700 – 40,000 ft	100% Oxygen
Above 40,000 ft	100% Oxygen UNDER PRESSURE
Above 50,000 ft	Sealed cabin + Pressure suit
Above 63,000 ft	Armstrong's Line — body fluids boil
Above 120 nm	Total space-equivalent — micro-G environment

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6.1 Numbers you MUST know by heart

Master cheat-sheet — Part 1 numbers

Parameter	Exact Value	Where it comes from
Top of troposphere (average)	13 km / 8.1 mi / 43,000 ft	§1 Atmospheric layers
Top of stratosphere (over)	100,000 ft	§1
Troposphere holds	75 % of atmospheric mass	§1
Nitrogen / Oxygen / Other	78.084 / 20.95 / ~1 %	§1.2
Water vapour content	1 – 4 % (variable)	§1.2
ISA sea-level pressure	1013.25 hPa = 760 mmHg = 29.92 inHg = 14.7 psi	§3.1
ISA lapse rate	1.98 °C / 1000 ft	§3.1
Tropopause altitude (ISA)	36,090 ft	§3.1
Isothermal temperature	-56.5 °C	§3.1
Cabin altitude maintained	6,000 – 8,000 ft	§4
O ₂ available at 18,000 ft	52 % (half of SL)	§4
O ₂ available at 36,000 ft	25 % (one-fourth of SL)	§4
Compensatory reactions begin	6,000 – 7,000 ft	§5.2
Pilot starts supplementary O ₂	10,000 ft	§5.1
Physiological-Deficient Zone	12,000 – 50,000 ft	§5.2

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Parameter	Exact Value	Where it comes from
Critical threshold (no O ₂ , unpressurised)	~22,000 ft	\$5.2
Safe altitude on 100% O ₂	~38,000 ft	\$5.2
100% O ₂ Under Pressure (PBA) from	Above 40,000 ft	\$5.1 fig.
Partial Space-Equivalent Zone	50,000 ft - 120 nm	\$5.3
Armstrong's Line (body fluids boil)	63,000 ft	\$5.4
Total Space-Equivalent Zone	Outwards from 120 nm	\$5.4

6.2 Common DGCA-style probe questions

Try answering these without looking back

1. State the percentage composition of nitrogen and oxygen in the atmosphere. *Does it change with altitude?*
2. Give the ISA sea-level values in **five** different units.
3. What is the ISA lapse rate, and up to what altitude does it apply?
4. Why does hypoxia occur with altitude, when the % of O₂ is unchanged? (*Hint: Dalton's Law.*)
5. At what altitude does a pilot normally start using supplementary oxygen?
6. State the four physiological zones with their altitude boundaries.
7. At what altitude does an unpressurised pilot, NOT using supplemental O₂, hit the critical threshold?
8. Why is a pressure suit mandatory above 50,000 ft? Quote Armstrong's Line value.
9. Explain Boyle's Law and give two flight-medical situations where it applies.
10. How does Henry's Law explain both hypoxia *and* decompression sickness?

MNEMONIC — 5 GAS LAWS "Bad Hens Cluck, Geese Dance" → Boyle · Henry · Charles · Graham · Dalton.

MNEMONIC — ZONES (LOW → HIGH) **P – P-D – PS – TS** → Physiological · Physiological-Deficient · Partial Space-equivalent · Total Space-equivalent. (Or: "Pilots Probably Prefer Tea" — P, PD, PS, TS.)

MNEMONIC — HALVING RULE "Half by Eighteen, Quarter by Thirty-Six" → Half of sea-level O₂ at **18,000 ft**; one-quarter at **36,000 ft**.

CPL · ATPL · Human Performance & Limitations Aviation Physiology & Human Factors

Part 2 of the master study set — The Brain & the Nervous System · The Respiratory System · The Circulatory System (Heart, Blood & its Failures)

CHAPTER

Chapter 26 (the DGCA reference textbook)

INSTRUCTOR

Ghost Aviator

EXAM

DGCA CPL / ATPL — HPL

SECTION

2 of N — The Body's Systems

Where we are in the chapter

Part 1 covered the **atmospheric envelope** you fly in — its layers, gases, gas laws, ISA values and the four physiological zones. Part 2 turns inward to the **three body systems** most affected by flight: the **nervous system** (which controls everything), the **respiratory system** (your interface with atmospheric oxygen), and the **circulatory system** (the delivery network). Mastering these three gives you the vocabulary needed for the big topics that follow — Hypoxia, Hyperventilation, Smoking, Alcohol and Blood Pressure.

Contents – Part 2

- | | |
|--|--|
| 1. The Brain & the Nervous System | 9. — Breathing & Its Regulation |
| 2. — The Brain | 10. The Circulatory System |
| 3. — The Central Nervous System (CNS) | 11. — The Heart & Cardiac Output |
| 4. — The Peripheral Nervous System (PNS) | 12. — Systole & Diastole — How the Heart Works |
| 5. — The Autonomic Nervous System (ANS) | 13. — Pulse Rate |
| 6. The Respiratory System | 14. — Composition & Function of the Blood |
| 7. — Air Pathway & Alveolar Gas Exchange | 15. — Failures of the Circulatory System (Angina & Heart Attack) |
| 8. — External vs Internal Respiration | 16. — Self-Check & Memory Aids |

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§ 7

The Brain & the Nervous System

The brain is the master controller of your body — every input you receive in flight (visual, vestibular, proprioceptive, auditory) is processed here, and every output (control inputs, R/T calls, decisions) originates here. The nervous system is the wiring that connects the brain to every organ and muscle.

7.1 The Brain

Definition



The brain controls all bodily functions. It performs an incredible number of tasks, every one of which is potentially flight-critical.

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What the brain does — exam list

- It controls **body temperature, blood pressure, heart rate and breathing.**
- It accepts information about the world around you from your various **senses** — seeing, hearing, smelling, tasting and touching.
- It handles your **physical movement** when walking, talking, standing or sitting.
- It lets you **think, dream, reason and experience emotions.**
- The brain controls **decision-making and speech.** Through the brain we experience **consciousness, vision, hearing, taste, smell, thought and memory.**

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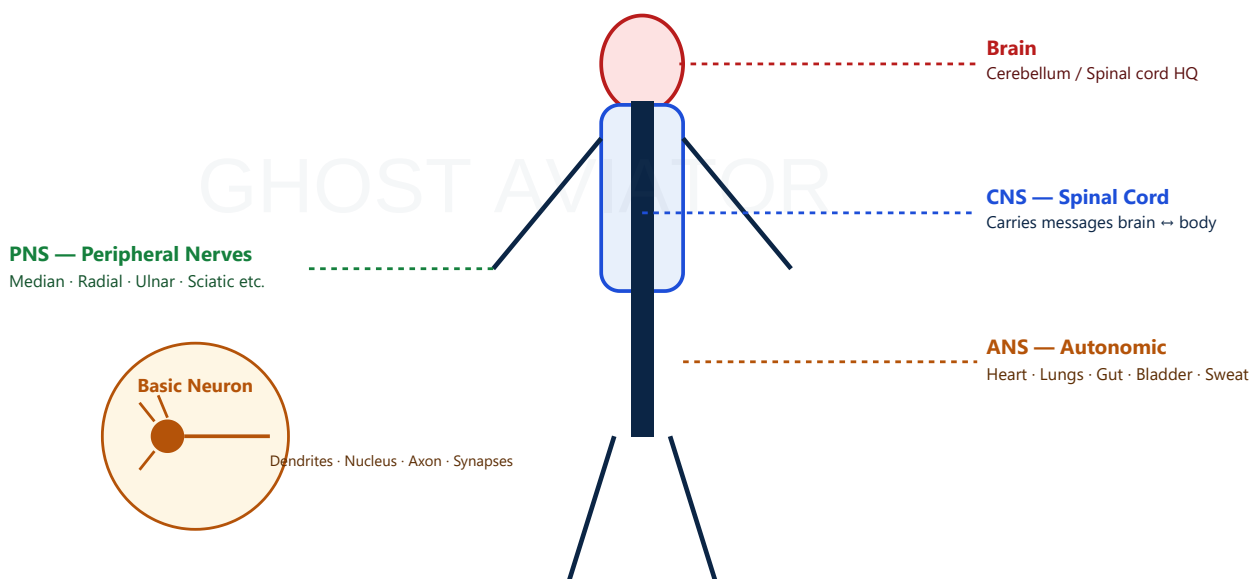
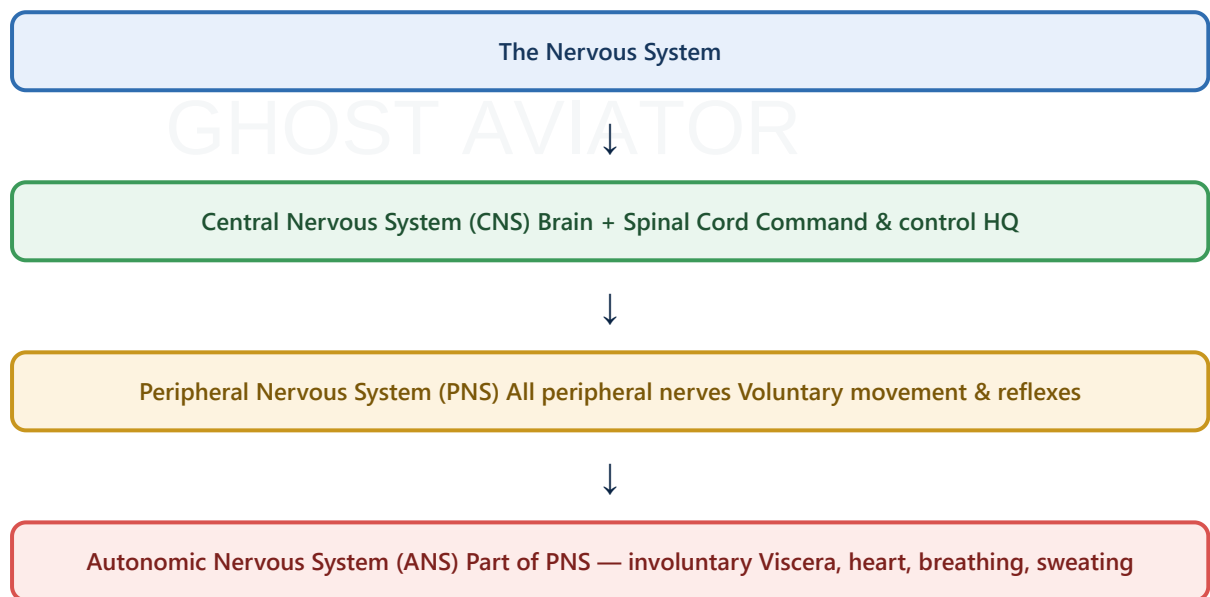
Why this matters in the cockpit



Every one of these functions is **oxygen-dependent**. The brain consumes about **20 % of the body's oxygen** despite being only ~2 % of body mass. Even mild hypoxia degrades judgement, decision-making and speech long before the pilot is consciously aware of it. (Detailed in §10 Hypoxia — Part 3.)

7.2 The Nervous System — Three Main Parts

The Nervous System is divided into **three main parts**:



The nervous system has three parts — CNS (brain + spinal cord), PNS (all peripheral nerves), and ANS (involuntary control of viscera).

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The Central Nervous System (CNS)

Definition



The central nervous system consists of the **brain and the spinal cord**. The brain, spinal cord and peripheral nerves make up a **complex, integrated information-processing and control system known as Central Nervous System**. In tandem, they regulate **all the conscious and unconscious facets of your life**.

- The scientific study of the brain and nervous system is called **neuroscience** or **neurobiology**.
- The **brain** functions to **receive nerve impulses from the spinal cord and cranial nerves**.
- The **spinal cord** contains the nerves that **carry messages between the brain and the body**.

The Peripheral Nervous System (PNS)

Function



The peripheral nervous system includes **all peripheral nerves**. It **connects the central nervous system to the organs and muscles** of the body and regulates **all purposeful and reflex actions**. The peripheral nervous system controls organs and muscles like **skin, eye, blood vessels, heart and stomach**.

The Autonomic Nervous System (ANS)

Definition



The organs (the "**viscera**") of our body — such as the **heart, stomach and intestines** — are regulated by a part of the nervous system called the **Autonomic Nervous System (ANS)**. The ANS is **part of the peripheral nervous system**, and it controls many organs and muscles within the body.

Key characteristic — it works without you knowing



In most situations, we are unaware of the workings of the ANS because it functions in an **involuntary, reflexive manner**. For example, we do not notice when blood vessels change size or when our heart beats faster.

The Autonomic Nervous System exercises its functions **independently of the Central Nervous System** to the extent that it controls parts of the body without having to think about it.

What the ANS controls — full DGCA list

SENSORY Eye	CARDIAC Heart	RESPIRATORY Breathing
THERMOREGULATION Temperature	VASCULAR Blood Pressure	DIGESTIVE Stomach & Intestines
EXCRETORY Urinary Output & Bladder	COOLING Sweating & Glands	STRESS RESPONSE Fight-or-Flight Reaction

Flight-relevance — the "Fight or Flight" reflex



The ANS controls the **fight-or-flight response or reaction to stress**. In a sudden emergency — engine failure, severe turbulence, near-miss — the ANS dumps adrenaline into your bloodstream automatically. Heart rate, breathing rate, BP and sweating all spike **without your conscious permission**. *This is why a well-trained pilot's drilled checklist beats raw reaction: the conscious brain must override an autonomic surge.*

Three divisions of the Nervous System — quick comparison

Division	What it Contains	What it Controls	Conscious / Involuntary
Central NS	Brain + Spinal Cord	Receives, processes & commands all activity	Both
Peripheral NS	All peripheral nerves	Skin, eye, blood vessels, heart, stomach & muscle action	Both — voluntary & reflex
Autonomic NS	Sub-system of PNS	Eye · Heart · Breathing · Temp · BP · GI · Bladder · Sweat · Stress	Involuntary only

Overall purpose — one sentence



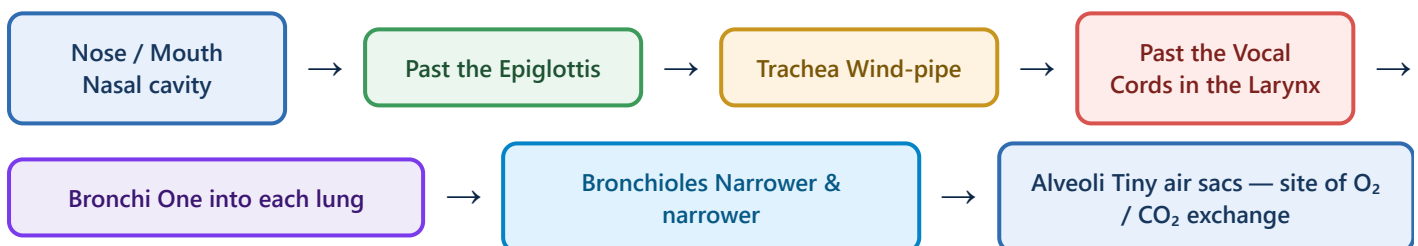
Lungs are complex organs, but what they do is to get rid of carbon dioxide and exchange it for oxygen.

The respiratory process consists mainly of:

- the **diffusion of oxygen through the respiratory membranes into the blood,**
- **transportation to the cells,**
- **diffusion into the cells, and**
- **elimination of carbon dioxide from the body.**

8.1 The Pathway of Air — Nose to Alveoli

As you breathe air in through your nose or mouth, it travels along this path:



Anatomical landmarks — memorise these labels



1. A — Nasal cavity

2. B — Pharynx

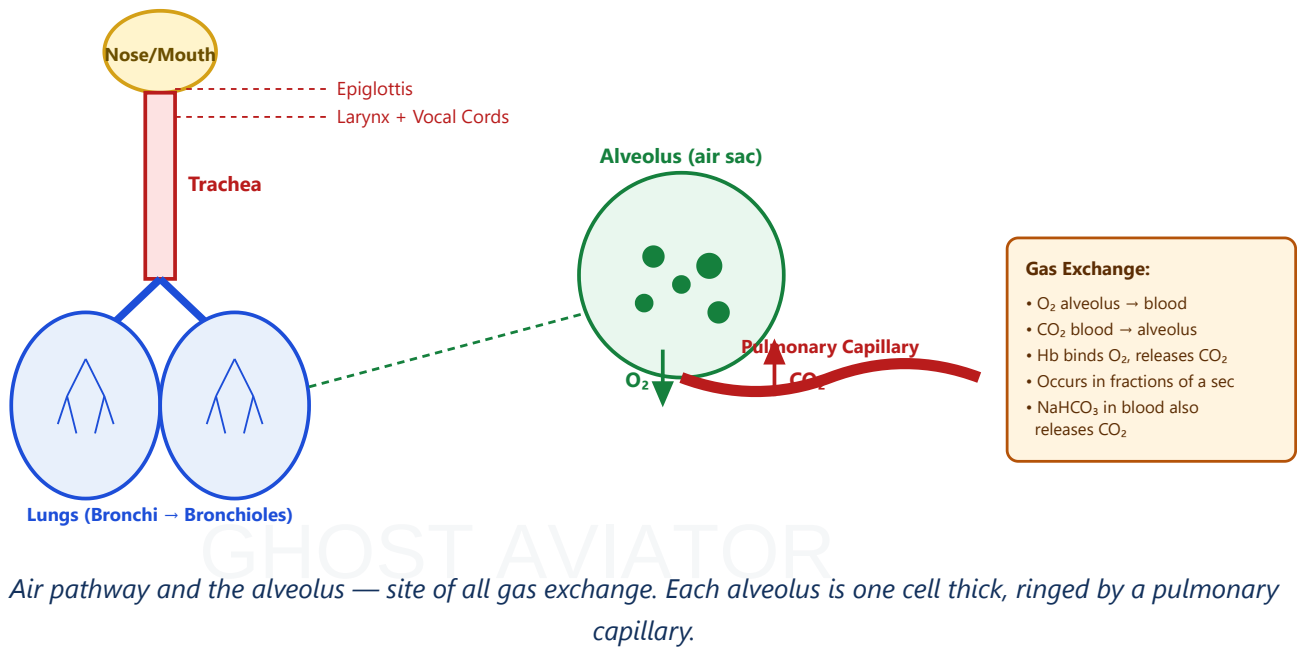
3. C — Larynx (houses the vocal cords)

4. D — Trachea

5. E — Alveoli

6. F — Bronchial tree

7. G — Diaphragm



8.2 What Happens Inside the Alveolus — Gas Exchange

The diffusion sequence (Graham's Law in action)

1. Within each air sac, the **oxygen concentration is high**, so oxygen passes or **diffuses across the alveolar membrane into the pulmonary capillary**.
2. At the beginning of the pulmonary capillary, the **haemoglobin** in the red blood cells has **carbon dioxide bound to it and very little oxygen**.
3. The oxygen **binds to haemoglobin**, and the carbon dioxide is **released**.
4. **Carbon dioxide is also released from sodium bicarbonate dissolved in the blood** of the pulmonary capillary.
5. The concentration of carbon dioxide is high in the pulmonary capillary, so CO₂ **leaves the blood and passes across the alveolar membrane into the air sac**.
6. This exchange of gases occurs **rapidly (fractions of a second)**.
7. The carbon dioxide then leaves the alveolus (tiny air sacs of the lungs which allow for rapid gaseous exchange) when you **exhale**, and the **oxygen-enriched blood returns to the heart**.

The purpose, in one line



The purpose of breathing is to keep the **oxygen concentration HIGH** and the **carbon dioxide concentration LOW** in the alveoli, so this gas exchange can occur.

8.3 External vs Internal (Tissue) Respiration

External Respiration

External Respiration takes place through the **lungs** and refers to:

- The **absorption of Oxygen from the air into the blood.**
- The **excretion of Carbon Dioxide from the blood to the air.**

Internal / Tissue Respiration

Internal or Tissue Respiration refers to the **transfer of Oxygen from the blood to the tissues** of the body. At the same time as this occurs, the tissues **give up Carbon Dioxide to the blood.**

QUICK TEST External = at the **LUNGS** (air ↔ blood). Internal = at the **TISSUES** (blood ↔ cell).

Don't mix these up — examiners love this distinction.

8.4 Breathing

Definition



Normal breathing is a **purely automatic process under the unconscious control of the nervous system**. The normal rate of respiration in adults is **14 to 18 breaths per minute**.

What regulates your breathing rate — counter-intuitive but vital

The level of carbon dioxide in the blood effectively regulates the rate and depth of breathing.



It is **NOT oxygen** that triggers your urge to breathe — it is **rising CO₂**. This is the core mechanism behind **Hyperventilation** (over-breathing → CO₂ washes out → urge to breathe drops → tingling, dizziness) which is dealt with separately in Part 3.

NORMAL ADULT RESPIRATION
RATE

14 – 18 / min

CONTROL CENTRE

Medulla (Autonomic)

PRIMARY STIMULUS

Blood CO₂ Level

CONSCIOUS OVERRIDE

Possible (limited)

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Why it exists



Blood supplies our organs with life-giving oxygen and carries away waste products. The circulatory system consists of the **heart and the blood vessels**, and maintains the **flow of blood throughout the body**. Without it, gas exchange at the lungs is pointless — there must be a delivery network.

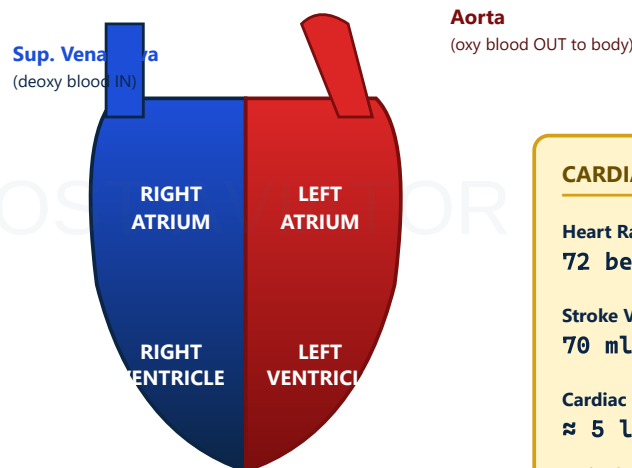
9.1 The Heart

What the heart does — concise

The arteries **carry blood from the heart at HIGH pressure**, and the veins **return blood to the heart at LOW pressure**. The heart is a **pumping system** which:



- Intakes **de-oxygenated blood through the veins**.
- Delivers it to the **lungs for oxygenation**.
- Then pumps it into the various **arteries to be transmitted** where it is needed throughout the body for energy.



CARDIAC OUTPUT AT REST

Heart Rate
72 beats / min

Stroke Volume
70 ml

Cardiac Output
≈ 5 litres / min

= Blood pumped in 1 min

The four chambers of the heart. RIGHT side handles deoxygenated blood (blue) routed to the lungs; LEFT side handles oxygenated blood (red) routed to the body via the aorta.

Memorise — cardiac output values

At rest the **cardiac output** (the quantity of blood the heart pumps in one minute) of an adult with:



- Heart Rate = **72 beats per minute**
- Stroke Volume = **70 mL**

... is **about 5 litres per minute**. (Stroke volume × Heart rate = Cardiac output.)

9.2 How the Heart Works — Systole & Diastole

Two phases of the cardiac cycle



When the heart muscle contracts or beats (called **SYSTOLE**), it **pumps blood out of the heart**. Then the heart muscle relaxes (called **DIASTOLE**) before the next heartbeat. This allows blood to **fill up the heart again**.

The two-stage contraction of systole

- Stage 1:** The **right and left atria contract at the same time**, pumping blood to the right and left ventricles.
- Stage 2:** The **ventricles contract together** to propel blood out of the heart.

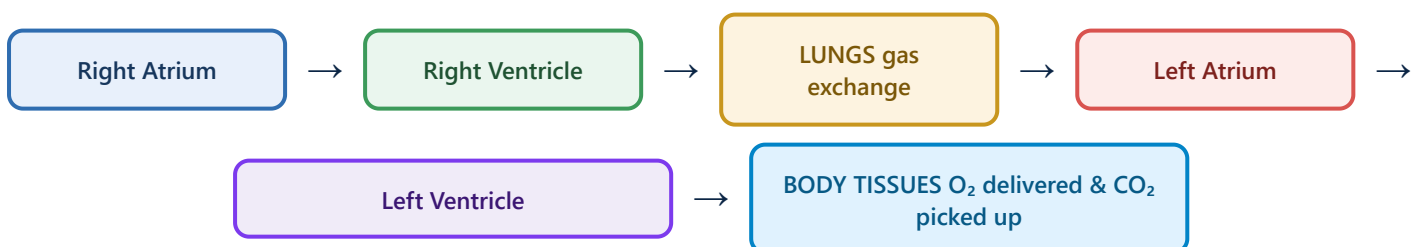
The two-sided traffic plan

Right Side of the Heart

Collects **oxygen-poor blood from the body** and pumps it to the **lungs**, where it picks up oxygen and releases carbon dioxide.

Left Side of the Heart

Collects **oxygen-rich blood from the lungs** and pumps it to the **body**, so that the cells throughout your body have the oxygen they need to function properly.



Blood's journey from left ventricle to capillaries



Blood containing oxygen is pumped around the body from the **left ventricle**. The oxygenated blood passes through the **aorta into the arteries** before arriving at the smallest vessels of the system, the **capillaries**. The **Oxygen–Carbon Dioxide exchange takes place through the walls of the capillaries**.

9.3 Pulse Rate

Definition

The normal rate of the **pulse is the rate of the heartbeat**. A healthy person at rest has a pulse rate of between **60 and 80 beats per minute**. The rate is increased by:



- Exercise
- Emotional inputs
- Disease

Stress & fear — autonomic adrenaline surge



When the body experiences **stress or fear**, **adrenaline is released into the bloodstream** causing an **immediate increase in the pulse rate**. (This is the ANS "fight-or-flight" response from §7.4.)

RESTING PULSE (HEALTHY)

60 – 80 bpm

CARDIAC OUTPUT REFERENCE

72 bpm × 70 ml

OUTPUT PER MINUTE

≈ 5 L/min

ADRENALINE EFFECT

Immediate ↑ pulse

9.4 Composition & Function of the Blood

Two main components of blood

Blood has **two main components — PLASMA and FORMED ELEMENTS**.



- **Plasma:** Nearly everything that blood carries — including **nutrients, hormones and waste** — is dissolved in plasma, which is **mostly water**.
- **Formed elements:** Cells and parts of cells that also **float in plasma**.

Formed elements — the three cell types

Cells and cell-fragments in the blood

Element	What it is / does	Notes
White Blood Cells (WBCs)	Part of the immune system	White corpuscles produce antibodies to fight bacteria.
Platelets	Help form clots	Smallest of the blood cells ; assist in the blood-clotting process.
Red Blood Cells (RBCs)	Carry oxygen & carbon dioxide	Numerous — make up more than 90 % of the formed elements in the blood . Virtually everything about them helps them carry oxygen more efficiently.

Inside a Red Blood Cell — Haemoglobin (Hb)

Structure of haemoglobin — DGCA-favourite question

A red blood cell's lack of nucleus also gives it **more room for haemoglobin (Hb)**, a complex molecule that carries oxygen. It is made of:



- A protein component called **GLOBIN**.
- **FOUR pigments called HEMES**.
- The hemes use **IRON** to bond to oxygen.

Inside each RBC are **≈ 280 million haemoglobin molecules**.



5 Functions of Blood

1. Carry O₂ & CO₂ to/from tissues
2. Carry nutrients · remove waste
3. Carry hormones (e.g. adrenaline)
4. Carry immune cells — fight microbes
5. Help regulate body temperature

Each RBC packs ~280 million haemoglobin molecules; each Hb has 4 iron-bearing hemes that grip oxygen, plus the globin protein backbone.

If you lose a lot of blood...

Why blood loss is dangerous



If you lose a lot of blood, you lose a lot of your **oxygen delivery system**. The immune cells, nutrients and proteins that blood carries are important too, but doctors are generally **most concerned with whether your cells are getting enough oxygen**.

Emergency management

In an emergency situation, doctors will often give patients **volume expanders**, like **saline**, to make up for lost blood volume. This:



- Helps restore **normal blood pressure**.
- Lets the remaining red blood cells **continue to carry oxygen**.
- Sometimes is enough to keep the body going until it can produce new blood cells and other blood elements.

If not, doctors give **blood transfusions** to replace some of the lost blood. Blood transfusions are also fairly common during some **surgical procedures**.

The principal functions of the blood — full DGCA list

The five principal functions of blood

#	Function	Mechanism
1	Carry oxygen to, and carbon dioxide from , the various tissues and organs of the body.	Haemoglobin in RBCs
2	Carry nutrients to tissues and remove waste products from these tissues.	Dissolved in plasma
3	Carry chemical messengers, such as hormones including ADRENALINE , to regulate the actions and secretions of various organs.	Plasma transport
4	Transport cells which can attack and destroy invading micro-organisms , enabling the body to resist disease.	WBCs / antibodies
5	Assist in temperature control of the body.	Vasodilation/constriction

9.5 Failures or Malfunctions of the Circulatory System

Two principal failure modes

The circulatory system can malfunction in **two principal ways**:



1. The main component of the system, the **heart and the blood vessels**, may develop a fault.
2. The **blood may become unable to carry enough Oxygen** for the need of the organs and tissues of the body.

Angina & Heart Attack

Definitions



A **lack of oxygen supply to the heart** may give rise to symptoms of **Angina**. A **heart attack** is when **low blood flow causes the heart to starve for oxygen**. Heart muscle **dies or becomes permanently damaged**. Your doctor calls this a **myocardial infarction**.

Causes of angina and heart attack

The blood-clot mechanism



- Most heart attacks are caused by a **blood clot that blocks one of the coronary arteries**.
- The **coronary arteries bring blood and oxygen to the heart**. If the blood flow is blocked, the heart starves for oxygen and heart cells die.
- A clot most often forms in a coronary artery that has become **narrow because of the build-up of a substance called PLAQUE** along the artery walls.
- Sometimes, **the plaque cracks and triggers a blood clot to form**.
- Occasionally, **sudden overwhelming stress can trigger a heart attack**.

Risk factors for angina and heart attack — the full DGCA list

Risk factors — pilots should be screened for these at every medical

Risk Factor	Why it matters
Bad genes (hereditary factors)	Family history is non-modifiable but flagged in flight-medical examinations.
Being male	Higher statistical risk than females (until menopause for women).
Diabetes	Damages blood-vessel linings and accelerates plaque build-up.
Getting older	Arterial elasticity falls; plaque accumulation rises.
High blood pressure	Damages arterial walls — central to plaque mechanism. (<i>See §14 in next part.</i>)
Smoking	Reduces O ₂ -carrying capacity 5–8 %, raises BP, accelerates atherosclerosis. (<i>§12 — next part.</i>)
Too much fat in your diet	Raises LDL cholesterol — primary feedstock for plaque.
Unhealthy cholesterol levels — especially HIGH LDL ("bad") cholesterol and LOW HDL ("good") cholesterol	Direct correlation with coronary artery narrowing.
Lack of exercise	Increases all of the above; lowers cardiac reserve.
Stress	Sustained adrenaline release damages the heart and vessels.
Obesity	Independent risk factor + driver of diabetes, BP, lipids.
Alcohol	Raises BP, damages heart muscle, raises triglycerides. (<i>§13 — next part.</i>)

Why pilots care — DGCA medical implications



Every one of these risk factors is screened at Class-I & Class-II DGCA medicals via ECG, lipid panel, fasting glucose, BMI, blood pressure measurement and history. *Even an unsuspected silent angina is a fitness-defeating condition; routine cardiac screening exists precisely because the in-flight failure mode is sudden incapacitation.*

Insufficiency of Oxygen — the second failure mode

Why this is its own category



The second principal way the circulatory system can malfunction is "**Insufficiency of Oxygen**" — the blood becoming **unable to carry enough oxygen for the needs of the organs and tissues**. This is the gateway concept that leads directly into the next major topic — **HYPOXIA** — covered in detail in §10 (Part 3). Hold the term in mind.

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9.6 Self-Check & Memory Aids — Part 2

Numbers you must know cold

Master cheat-sheet — Part 2 numbers

Parameter	Exact Value	Where
Normal adult respiration rate	14 – 18 breaths/min	\$8.4
Primary regulator of breathing rate	Blood CO ₂ level	\$8.4
Resting pulse (healthy)	60 – 80 bpm	\$9.3
Reference heart rate (for CO calc)	72 bpm	\$9.1
Stroke volume (reference)	70 mL	\$9.1
Cardiac output at rest	≈ 5 L/min	\$9.1
RBCs as % of formed elements	> 90 %	\$9.4
Haemoglobin molecules per RBC	≈ 280 million	\$9.4
Hemes per Hb molecule	4	\$9.4
Metal that bonds O ₂ to heme	Iron	\$9.4
Protein component of Hb	Globin	\$9.4
Heart attack medical term	Myocardial Infarction	\$9.5
"Bad" cholesterol	LDL (high = bad)	\$9.5
"Good" cholesterol	HDL (high = good)	\$9.5

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DGCA-style probe questions

Try these without looking back

1. State the three main divisions of the Nervous System. Which one controls the heart, lungs and gut *without* conscious effort?
2. Trace the path of air from the nose to the alveoli — name **every** structure.
3. What is the difference between External and Internal Respiration?
4. What is the normal adult respiration rate, and what is the primary regulator of breathing?
5. Define cardiac output. Compute it for HR 72 bpm, SV 70 ml.
-  6. What is the difference between Systole and Diastole? Describe the two-stage contraction.
7. State the two main components of blood and the three types of formed elements.
8. How many haemoglobin molecules are inside each RBC? How many hemes per Hb?
9. List the five principal functions of blood.
10. What are the two principal failure modes of the circulatory system? Name the medical term for a heart attack.
11. List at least eight risk factors for angina/heart attack relevant to a DGCA medical.
12. What is plaque, and why does it matter to coronary arteries?

MNEMONIC — AIR PATHWAY "Never Pinch The Lazy Bronchitis Boy's Alveoli" → Nose · Pharynx · Trachea · Larynx · Bronchi · Bronchioles · Alveoli. (Note the epiglottis sits between nose/pharynx and trachea acting as the airway gatekeeper.)

MNEMONIC — 3 NS DIVISIONS "Cops Patrol Automatically" → CNS (Central — Brain + Cord, the HQ) · PNS (Peripheral — all peripheral nerves, the patrol) · ANS (Autonomic — runs without orders).

MNEMONIC — CARDIAC OUTPUT $CO = HR \times SV$ → Cardiac Output = Heart Rate × Stroke Volume. $72 \times 70 \approx 5040 \text{ ml} \approx 5 \text{ L/min}$.

MNEMONIC — RIGHT VS LEFT HEART "Right is BLUE, Left is RED" → Right side handles de-oxygenated blood (to lungs); Left side handles oxygenated blood (to body).

CPL · ATPL · Human Performance & Limitations Aviation Physiology & Human Factors

Part 3 of the master study set — HYPOXIA (the big one) · Carbon Monoxide Poisoning · Hyperventilation

CHAPTER

Chapter 26 (the DGCA reference textbook)

INSTRUCTOR

Ghost Aviator

EXAM

DGCA CPL / ATPL — HPL

SECTION

3 of N — The Silent Killers

Why Part 3 is the single most important block in this chapter

The DGCA HPL paper draws the **largest single share of questions** from the three topics covered in this part. More importantly — **these three conditions kill pilots every year**. Each one is *insidious*: by the time the symptoms register, judgement is already impaired. You must be able to **identify · diagnose · respond** with reflex speed.



Read every line. Memorise every list. Practise the immediate-action steps until they're checklist-instinctive.

Contents – Part 3

- | | |
|---|--|
| 1. §10 HYPOXIA — Definition & Cerebral Hypoxia | 10. — Altitude thresholds & night vision |
| 2. — Why hypoxia matters to a pilot | 11. §11 Carbon Monoxide (CO) Poisoning |
| 3. — Stages & clinical course (mild → coma → death) | 12. — CO – the colourless killer |
| 4. — The FOUR Types of Hypoxia | 13. — Symptoms · Actions · Prevention |
| 5. (a) Hypoxic Hypoxia | 14. §12 Hyperventilation — "Over-breathing" |
| 6. (b) Anemic Hypoxia | 15. — Causes at low altitude |
| 7. (c) Ischemic / Stagnant Hypoxia | 16. — Symptoms · Treatment · the paper-bag trick |
| 8. (d) Histotoxic Hypoxia | 17. — Hypoxia vs Hyperventilation — telling them apart |
| 9. — Causes · Symptoms · Immediate Actions (master table) | 18. Self-Check, Cheat-Sheet & Mnemonics |

§ 10

HYPOXIA

Technical definition — "cerebral hypoxia"



The term **cerebral hypoxia** technically refers to **lack of oxygen supply to the cerebral hemispheres** (the outer portion of the brain). However, it is more typically used to refer to a **lack of oxygen supply to the entire brain**.

10.1 Why Hypoxia Matters to a Pilot

Two ways the body can be starved of oxygen

1. The body's organs and tissues may be **deprived of the oxygen they need because of illness or disease**.



2. **But the pilot must know that oxygen deprivation or hypoxia can be caused by breathing air at low pressures at high altitude.**

This second category — **altitude-induced hypoxia** — is the aviator's main concern, and the form most commonly tested in DGCA exams.

Effect on the pilot — direct quote, memorise

Hypoxia will cause a pilot's intellectual and sensory judgment to become impaired. In mild cases, hypoxia causes only:



- Inattentiveness,
- Poor judgment, and
- Uncoordinated movement.

10.2 Stages & Clinical Course — from "tipsy" to lethal

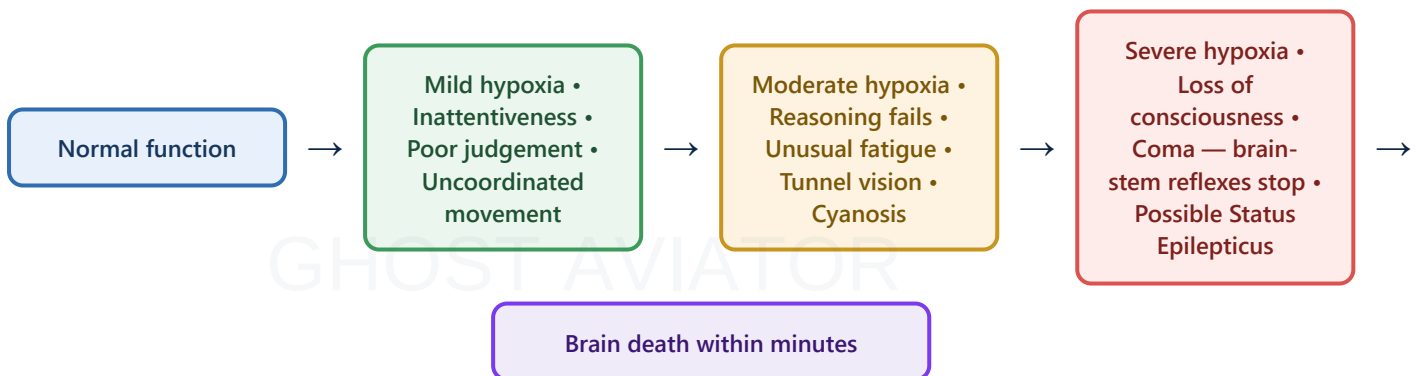
Severe cases — the cascade to death

Severe cases result in a state of complete unawareness and unresponsiveness (coma) — brain-stem reflexes, including response to light and the breathing reflex, stop. Only blood pressure and heart function are maintained. If this persists, brain death is inevitable.



If the lack of oxygen to the brain is limited to a **very brief period of time**, coma may be **reversible** with varying levels of return to function, depending on the extent of injury. Sometimes **seizures** may occur, which may be **continuous with no stop between them** — a condition called **STATUS EPILEPTICUS**.

Serious oxygen deprivation can kill a pilot within minutes.



Onset characteristic — note the word "insidious"

The symptoms are **slow but progressive, insidious in onset**, and are most marked at altitudes starting above **10,000 ft (3,500 m)**. Night vision, however, can be impaired starting at altitudes **5,000 ft**.



"Insidious" means it *sneaks up on you*. You will not realise you are hypoxic — that is the entire problem. Your buddy in the right seat may notice it before you do.

Why "euphoria" is the most dangerous early symptom



The onset of hypoxia **may be accompanied by a feeling of well-being, known as EUPHORIA.** The pilot feels good — even *great* — and is therefore the **last person in the cockpit** who will suspect anything is wrong. This is why CRM and crew cross-checks are critical above 10,000 ft.

10.3 The FOUR Types of Hypoxia



Classification — opening line of every DGCA hypoxia question

HYPOXIA IS CLASSIFIED INTO FOUR DIFFERENT TYPES:

TYPE (a)

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Hypoxic Hypoxia

Cause: low oxygen *levels* in the bloodstream.

The pilot's type: in pilots, this most often occurs with **exposure to altitude — hypobaric hypoxia.** At low altitudes the partial pressure of oxygen is adequate to maintain brain function at peak efficiency. **Atmospheric pressure and the partial pressure of oxygen both decline at higher altitudes.**

TYPE (b)

Anemic Hypoxia

Cause: blood cannot carry enough oxygen even though atmospheric oxygen may be plentiful. Oxygen in blood is carried by **haemoglobin**, which is found in red blood cells. When the **RBC count decreases**, or the **haemoglobin does not function properly**, less oxygen can be carried by the blood.

Occurs in: heavy bleeding · some cancers · sickle-cell anemia · **carbon monoxide poisoning**, to name a few. Symptoms: **breathlessness, fatigue, chest pain** — and they **worsen at higher altitudes**, as the effects of hypoxia and anemia are **additive**.

TYPE (c)

Ischemic / Stagnant Hypoxia

"Ischemia" = inadequate supply of blood. **Ischemic hypoxia** occurs when there is **inadequate blood flow to body tissues**.

Occurs in:

- **Constriction of blood vessels** (e.g. fingers and toes exposed to cold).
- **Low blood pressure / low cardiac output** such as fainting.

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- **Exposure to high sustained accelerations** like excessive G-forces (stagnant hypoxia).

Oxygen therapy is not very helpful in this form. The **best remedy is to correct the underlying cause**.

TYPE (d)

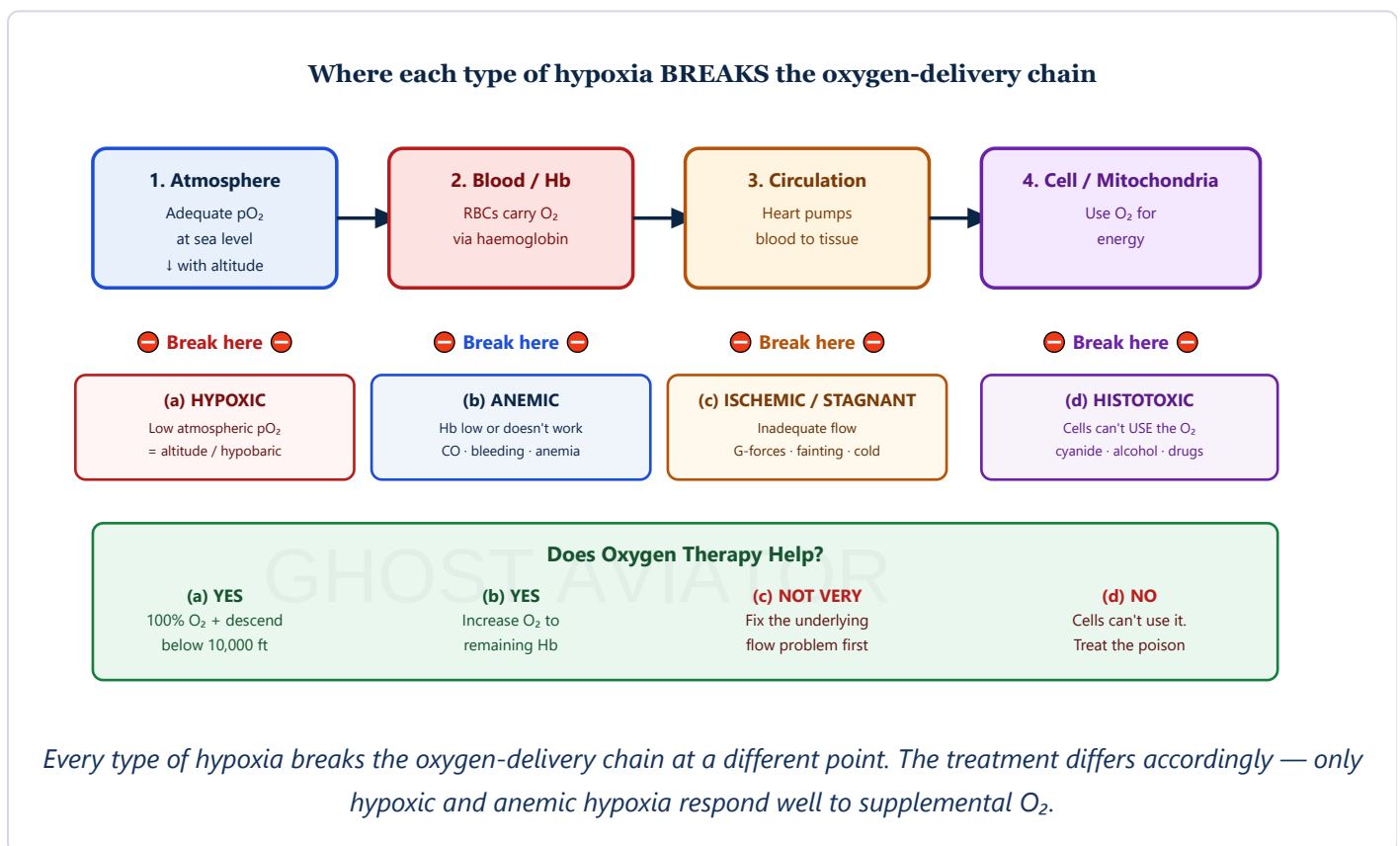
Histotoxic Hypoxia

Cause: the **inability of the cells of the body to use the oxygen available**. The oxygen is there in the blood, in the tissues — but the cells can't metabolise it.

Rare in pilots, but can occur with:

- **Cyanide poisoning,**
- **Chemical poisoning,**
- **Intoxication with certain drugs.**

Can also be caused by HIGH BLOOD ALCOHOL LEVELS. (Direct link to §14 in Part 4.)



10.4 Causes · Symptoms · Immediate Actions — Master Table

The DGCA syllabus consolidates Hypoxia management into **one master tabulation** of all causes, all symptoms, and the immediate actions if hypoxia is suspected. This is reproduced verbatim below.

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Hypoxia — Causes, Symptoms & Immediate Actions (verbatim DGCA syllabus table)

Hypoxia Causes	Symptoms	Immediate Actions if Hypoxia is suspected
• Drug overdose / alcohol • Asphyxiation caused by smoke inhalation • Very low blood pressure • Strangulation • Cardiac arrest (when the heart stops pumping) • Carbon monoxide poisoning • High altitudes • Choking • Compression of the trachea • Diseases that paralyze the respiratory muscles • A tobacco smoker is likely to experience the effects of hypoxia at a lower altitude than a non-smoker	• The symptoms are slow but progressive, insidious in onset, and are most marked at altitudes starting above 10,000 ft (3,500 m). Night vision can be impaired starting at altitudes 5,000 ft. • Its onset may be accompanied by a feeling of well-being, known as EUPHORIA. • Even minor hypoxia impairs night vision and slows reaction time. • More serious hypoxia interferes with reasoning, gives rise to unusual fatigue and, finally, results in loss of consciousness / death. • Impaired Judgment • Headache • Tingling in hands & feet • Hyperventilation (yes, hypoxia can <i>trigger</i> hyperventilation) • Muscular Impairment • Memory Impairment • Sensory Loss • Tunnel Vision • Cyanosis (a bluing of the body extremities) • Formication (a feeling of ants under the skin)	• Provide Oxygen. • Descend below 10,000 feet or Minimum Safe Altitude if it is higher than 10,000 ft.

Memorise — the IMMEDIATE-ACTION drill (a 2-step reflex)

1. **PROVIDE OXYGEN** — don the mask, 100 % flow, regulator to "EMERGENCY" if available.



2. **DESCEND BELOW 10,000 ft** (or below MSA — Minimum Safe Altitude — if MSA is higher than 10,000 ft).

This is the standard DGCA-examined answer. Do not over-elaborate in the exam — write these two steps in this order.

10.5 Altitude Thresholds & Night Vision

NIGHT VISION IMPAIRMENT
FROM

5,000 ft

DAY SYMPTOMS MARKED
FROM

10,000 ft (3,500 m)

ACTION THRESHOLD —
DESCEND BELOW

10,000 ft

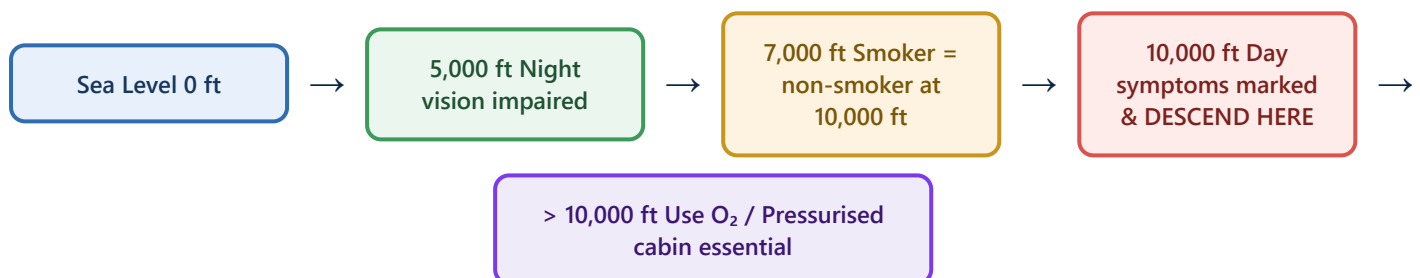
SMOKER EFFECTIVE ALTITUDE
(RECAP)

≈ 7,000 ft

DGCA reasoning the examiner is testing



The reason the action threshold is **10,000 ft** and not, say, 14,000 ft is because **symptoms are most marked at altitudes starting above 10,000 ft (3,500 m)**. The reason supplemental O₂ is required **at night above 5,000 ft** in many jurisdictions is because **night vision is impaired starting at 5,000 ft** — the rod cells in the retina are extraordinarily sensitive to even mild hypoxia. (*Vision pathophysiology is dealt with in a later part of this chapter.*)



§ 11

Carbon Monoxide (CO) Poisoning

11.1 The Colourless Killer

What CO is



Carbon monoxide is a **colourless, odourless, tasteless gas** that is a **product of incomplete combustion**.

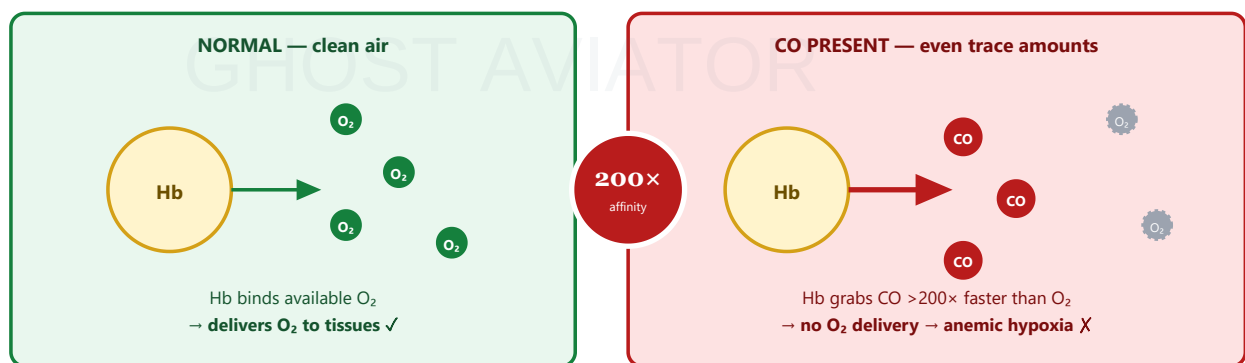
Why CO is so dangerous — the 200× rule

Haemoglobin, the oxygen-carrying chemical in the blood, picks up carbon monoxide **over 200 times more readily** than it picks up oxygen.



Thus, even **minute quantities in the cockpit** (often from improperly vented exhaust fumes) **may result in pilot incapacitation**. Exhaust gases from piston engines can consist of **as much as 9 % carbon monoxide**. So, gases from **leaking exhausts** can cause carbon monoxide poisoning in pilots.

Hb vs O₂ | Hb vs CO — the 200:1 affinity problem



CO has more than 200× the affinity for haemoglobin compared to oxygen. Trace cockpit concentrations from a leaking exhaust can saturate Hb and cause "anemic hypoxia" even with plenty of oxygen in the air.

Sources of cockpit CO — the usual suspects



- **Improperly vented exhaust fumes** entering the cabin via the heating system.
- **Leaking exhaust manifolds / muffler shrouds** (especially common in piston singles where cabin heat is drawn over the exhaust).
- **Engine combustion gases**, which can contain up to 9 % CO.
- **Tobacco smoke** in confined cabins.

11.2 Symptoms • Actions • Prevention

Carbon Monoxide Poisoning – Symptoms

- **Initially, there is an INABILITY TO CONCENTRATE**
- Headache

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- Dizziness
- Nausea
- Impaired vision
- Lethargy or weakness
- Impaired judgment
- Personality change
- Impaired memory
- **Flushed cheeks and cherry-red lips** (*classic CO sign*)
- Convulsions

Actions if CO Poisoning is Suspected

1. **Turn off cabin heating**
2. **Open cabin ventilators**
3. **Consider using oxygen if available**
4. **Land as soon as possible**
5. **Take medical aid**
6. **Do not fly till cleared by doctor**



DGCA-quoted prevention rule — copy verbatim into your exam answer

AT ALL TIMES WHEN THE CABIN HEATING IS USED, FRESH AIR MUST BE CIRCULATED TO REDUCE PRESENCE OF CO.

Why the "cherry-red" colour?



Carboxyhaemoglobin (Hb-CO) is a *bright cherry red* — much brighter than oxygenated Hb. The pilot's cheeks and lips therefore flush bright pink/red. **Don't confuse this with the bluish CYANOSIS seen in hypoxic hypoxia.** They look opposite:

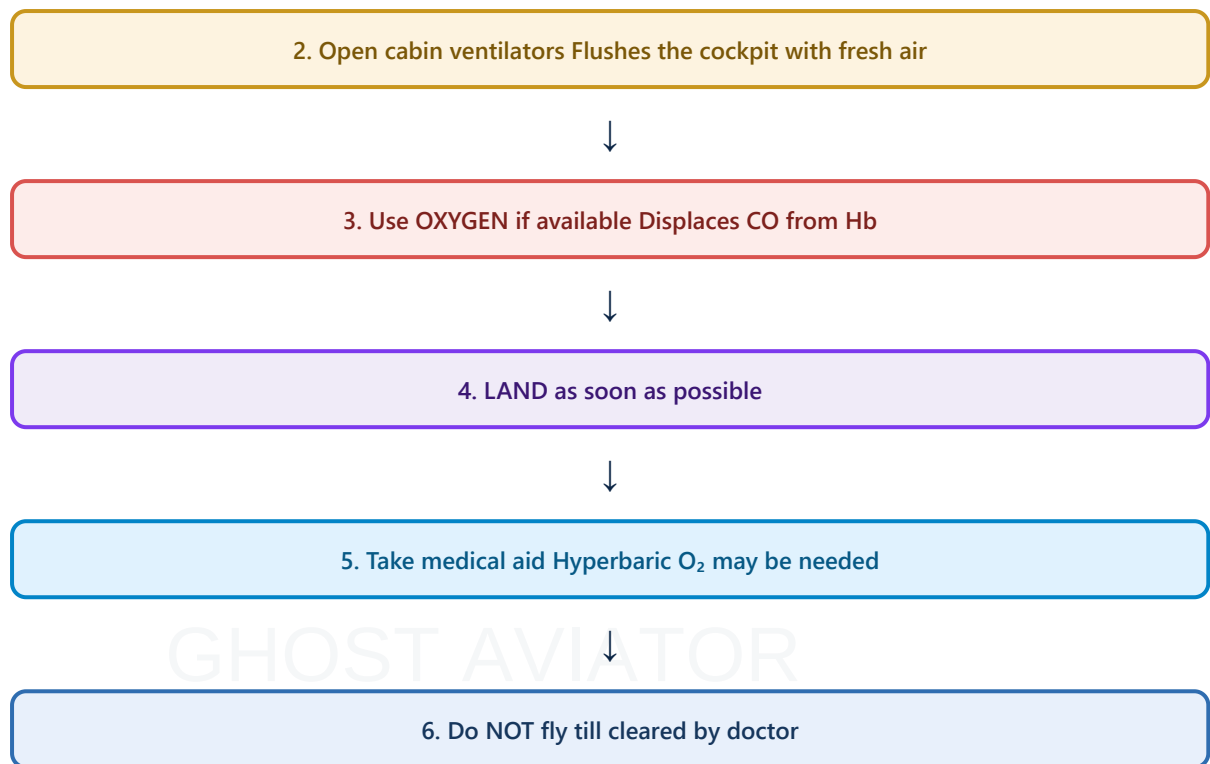
- **Hypoxic Hypoxia** → blue extremities (cyanosis)
- **CO Poisoning** → bright cherry-red lips/cheeks

Suspect CO poisoning headache · dizziness · cherry-red lips



1. Turn OFF cabin heating Removes the source





CO AFFINITY FOR HB (VS O ₂) > 200 x	CO IN PISTON-ENGINE EXHAUST up to 9 %	FIRST SYMPTOM Inability to concentrate
CLASSIC SKIN SIGN Cherry-red lips	FIRST ACTION Turn off cabin heat	HYPOXIA TYPE INVOLVED Anemic (Type b)

§ 12 Hyperventilation

Definition — "over-breathing"



"Hyperventilation" is another word for "over-breathing" and may be defined as **lung ventilation in excess of the body's needs. Good training is the best way to avoid Hyperventilation in pilots.**

Mitigation for passengers



The chances of Hyperventilation affecting your passengers can be reduced by **giving them a thorough pre-flight briefing on every aspect of the flying sortie.** (Briefed passengers = calm passengers; calm passengers don't hyperventilate.)

12.1 Causes at Low Altitude

At low altitude — where hypoxia is *not* a factor — the most common causes of hyperventilation are psychological or environmental rather than physiological.

The most common causes of Hyperventilation at low altitude

Category	Cause
Cognitive load	Intense concentration on a difficult task
Emotional	Fear
Emotional	Anxiety
Physical	Motion sickness
Physical	Shock
Environmental	Vibration
Environmental	Heat
Aerodynamic / Manoeuvring	High G-forces

12.2 Symptoms • Treatment • the Paper-Bag Trick

Symptoms of Hyperventilation

- Dizziness
- Tingling
- Visual disturbances
- Hot or cold sensation
- Anxiety
- Loss of muscular co-ordination
- Increased heart rate
- Spasms
- Loss of consciousness
- **Cramping and spasms of the hands and feet**
- Cold clammy skin

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- Paleness

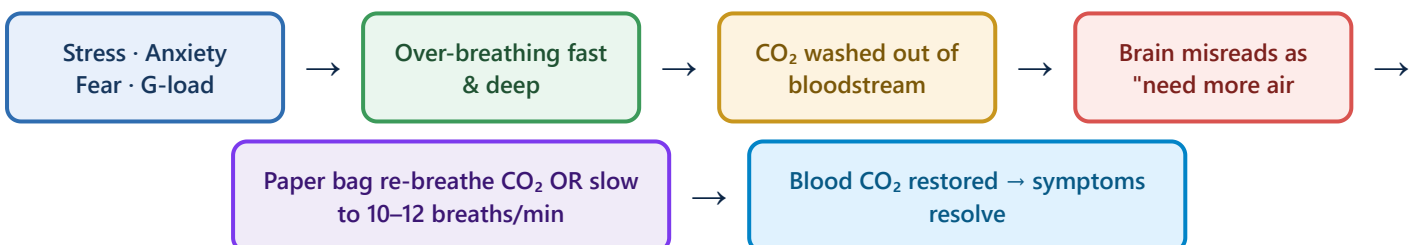
Treatment of Hyperventilation

1. **Breathe oxygen at 100 percent.** If hypoxia is the cause, the symptoms will improve markedly after **three or four breaths**.
2. **If the symptoms persist**, consciously slow the rate of breathing to **10–12 breaths per minute** and **do not breathe deeply**.
3. **If you are flying below 10,000 feet, hypoxia is unlikely and hyperventilation may be assumed.**
4. If you suspect that any occupant of your aircraft is suffering from hyperventilation, try to calm them down. Give them a **simple task to fulfill that might take their mind off their anxiety**.
5. One of the direct causes of hyperventilation is a **reduction in the carbon dioxide level in the blood**. The condition may be alleviated by getting the sufferer to **breathe into a PAPER BAG**. This action will **increase the blood's carbon dioxide level**, causing the brain to **reduce the breathing rate**.

The science behind the paper bag



Hyperventilation drives off too much CO₂ from the blood (**respiratory alkalosis**). Since the **brain's breathing centre is regulated by CO₂** (see §8.4), low CO₂ causes the urge to keep over-breathing — a vicious circle. A **paper bag** traps exhaled CO₂ which is then re-inhaled, raising blood CO₂ back to normal and breaking the loop.



12.3 Hypoxia vs Hyperventilation — Telling Them Apart

A vital distinction — the symptoms overlap

Many symptoms of hypoxia and hyperventilation overlap (dizziness, tingling, visual disturbances, loss of consciousness). The DGCA syllabus gives you a clean **altitude rule** to distinguish:



- **If flying BELOW 10,000 ft** → hypoxia is *unlikely* → **assume HYPERVENTILATION**.
- **If flying AT or ABOVE 10,000 ft** → hypoxia is plausible → **provide O₂ AND descend**. If symptoms clear after 3–4 breaths of 100 % O₂, it was hypoxia.

Hypoxia vs Hyperventilation — side-by-side

Parameter	Hypoxia	Hyperventilation
Typical altitude	> 10,000 ft	Any altitude (often below 10,000 ft)
Onset	Insidious, slow	Rapid — linked to a trigger (stress, fear)
Skin sign	Cyanosis (bluish)	Paleness · cold clammy skin
Heart rate	Often increased	Increased
Feeling of well-being?	Yes — euphoria	No — anxiety, fear
Blood CO ₂ level	Variable / often normal	LOW
First-line treatment	100 % O₂ + descend below 10,000 ft	Slow breathing to 10–12/min, or breathe into paper bag
How to confirm in flight	Symptoms improve in 3–4 breaths of 100 % O ₂	Symptoms persist on O ₂ ; resolve with re-breathing technique

EXAMINER'S FAVOURITE TRAP

A pilot at **9,500 ft** reports tingling in the fingers and dizziness. **Hypoxia is unlikely below 10,000 ft → assume hyperventilation.** Slow your breathing, calm down, optionally use a paper bag — do *not* declare an emergency and descend for a hypoxia event that isn't happening. (However — if O₂ is available, the standard advice "**breathe 100 % O₂; if symptoms clear in 3–4 breaths it was hypoxia**" lets you confirm safely.)

§ R3

Self-Check, Cheat-Sheet & Mnemonics

Join live classes for guided practice and doubt clearing.

— Part 3

Master cheat-sheet — Part 3 numbers

Every regulatory / clinical number from this part

Parameter	Exact Value	Where
Day-time hypoxia symptoms marked above	10,000 ft (3,500 m)	§10.5
Night vision impairment begins at	5,000 ft	§10.5
Smoker effectively at altitude of (vs non-smoker 10,000 ft)	7,000 ft	§10.4
Action on hypoxia — descend below	10,000 ft (or MSA if higher)	§10.4
Number of hypoxia types	FOUR	§10.3
CO affinity for Hb vs O ₂	> 200 ×	§11.1
Max CO content of piston exhaust gases	9 %	§11.1
Hyperventilation treatment — slow to	10 – 12 breaths/min	§12.2
Hypoxia confirmed if O ₂ relieves symptoms in	3 – 4 breaths	§12.2
"Below this altitude, assume hyperventilation"	< 10,000 ft	§12.2

Join live classes for guided practice and doubt clearing.

DGCA-style probe questions

Try these without looking back

1. Define *cerebral hypoxia*. How does it usually present (mild vs severe symptom set)?
2. List the FOUR types of hypoxia, with one cause for each.
3. A pilot at FL150 in an unpressurised aircraft reports euphoria and an inability to do mental arithmetic. What type of hypoxia, and what are the 2 immediate actions in correct order?
4. Why is supplemental oxygen *not* the right treatment for ischemic/stagnant hypoxia?
5. State the altitude at which **night vision** begins to be affected, and explain why.
6. By what factor does haemoglobin prefer CO over O₂? What is the maximum CO percentage in piston-engine exhaust?
7. List the six immediate actions if CO poisoning is suspected (in order). State the DGCA mandatory prevention rule about cabin heating.
-  8. Why does CO poisoning cause cherry-red lips? Contrast this with the skin sign of hypoxic hypoxia.
9. Define hyperventilation. Give five low-altitude causes.
10. Explain the physiology behind the "paper bag" treatment. What is the target breathing rate during recovery?
11. At 8,000 ft a passenger develops tingling fingers, light-headedness and pale clammy skin. What is the most likely diagnosis, and how do you treat it?
12. A pilot's symptoms vanish after four breaths of 100 % O₂. Was it hypoxia or hyperventilation?
13. Why does the same pilot reach his "hypoxia ceiling" earlier if he smokes? Give the approximate equivalent altitude figure.
14. Define *formication* and *cyanosis*. In which condition would you expect each?
15. State the difference between "hypoxic hypoxia" and "anemic hypoxia". Which one is caused by CO poisoning?

Mnemonics — burn these into long-term memory

MNEMONIC — 4 TYPES OF HYPOXIA "HAIH" → Hypoxic · Anemic · Ischemic (Stagnant) · Histotoxic. Or memorably — "**How Aviators Inhale Hypoxia**".

MNEMONIC — HYPOXIA SYMPTOMS "He Hits The Hammer Making Many Strange Tunnel Cuts Forming" → **H**eadache · **H**yperventilation · **T**ingling · **H**ot/cold sensation · **M**uscular impairment · **M**emory impairment · **S**ensory loss · **T**unnel vision · **C**yanosis · **F**ormication.

MNEMONIC — HYPOXIA ACTIONS "O down, A down" → (1) **OXYGEN** on, (2) **ALTITUDE** down — below 10,000 ft or MSA if higher.

MNEMONIC — CO POISONING ACTIONS "H V O L M N" = **H**eat off · **V**ents open · **O**xygen on · **L**and ASAP · **M**edical aid · **N**o flying till cleared.

MNEMONIC — HYPERVENTILATION LOW-ALTITUDE CAUSES "I FAMS VH G" (I Fight Aero-Med Symptoms Via Heated G-loads) = **I**ntense concentration · **F**ear · **A**nxiety · **M**otion sickness · **S**hock · **V**ibration · **H**eat · **G**-forces.

MNEMONIC — "BELOW 10K, ASSUME HYPERVENTILATION" "Ten thousand: think Hyper, not Hypoxic." — keep this on a sticky-note inside your kneeboard.

MNEMONIC — CO'S 200× RULE "Two hundred times faster than air" — Hb grabs CO 200× more readily than O₂.

CPL · ATPL · Human Performance & Limitations Aviation Physiology & Human Factors

Part 4 of the master study set — Smoking · Alcohol · Blood Pressure (Hypertension)

CHAPTER

Chapter 26 (the DGCA reference textbook)

INSTRUCTOR

Ghost Aviator

EXAM

DGCA CPL / ATPL — HPL

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Why Part 4 sits exactly where it does

Parts 1–3 built the *scientific* foundation — atmosphere, body systems, hypoxia, CO, hyperventilation. Part 4 turns to **lifestyle factors a pilot can actually control**: smoking, alcohol intake, and blood pressure. Each one of these is a **direct multiplier of every condition you have just studied**. A smoker hits hypoxia 3,000 ft earlier than you. A pilot with a hangover has degraded coordination, judgement, AND hypoxia tolerance. Untreated hypertension is "a major cause of unfitness in pilots" — DGCA quotes it word-for-word. This part is examined for both *knowledge* and *application*.



Contents – Part 4

1. §13 SMOKING
2. — The 3,000-ft penalty: 10,000 ft becomes 7,000 ft
3. — The 5–8 % O₂-capacity hit
4. — The full medical-impact list
5. §14 ALCOHOL
6. — The 24-hour bottle-to-throttle rule
7. — Metabolism: 0.015 g/100 ml / hour
8. — "One drink at 6,000 ft = two at sea level"
9. — Recommended maximum intake (units & rules)
10. — BAC 40 mg/100 ml — the error-spike threshold
11. — Hangover & "masked hangover" warning
12. §15 BLOOD PRESSURE
13. — Definitions: Systolic vs Diastolic
14. — 120/80 — the normal benchmark
15. — Hypertension — causes & pilot unfitness
16. Self-Check, Cheat-Sheet & Mnemonics

13.1 The 3,000-ft Penalty — 10,000 ft becomes 7,000 ft

The single most-asked DGCA fact about smoking

A pilot who is also a smoker **may experience the symptoms of oxygen deprivation, or hypoxia, at a lower altitude (7,000 ft)** than a non-smoker (10,000 ft).



That is a **3,000-ft penalty**. The smoker walks into the cockpit already partway up the hypoxia ladder. Combine that with an unpressurised climb to FL080 and the smoker can be hypoxic *at cruise altitude* when the non-smoker beside him is still asleep.

7,000ft Smoker's effective hypoxia threshold

5–8% O₂-carrying capacity reduction — 1 pack/day

↑ Increased susceptibility to CO poisoning

13.2 The 5–8 % O₂-Capacity Hit

Why smoking handicaps you — direct quote



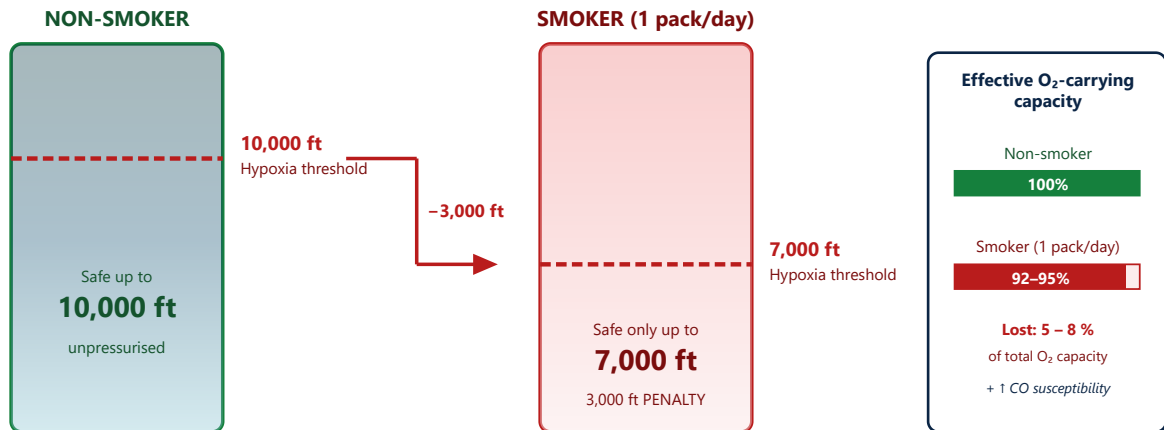
A person who smokes **one packet of cigarettes per day** will **reduce his capacity to carry oxygen by 5–8 %**. A smoker also has **increased susceptibility to Carbon Monoxide poisoning**.

The mechanism — anemic hypoxia, self-inflicted



Cigarette smoke contains **carbon monoxide**. Recall from §11.1 that CO binds to haemoglobin **over 200 times more readily** than oxygen. Every cigarette saturates a portion of your haemoglobin with CO — and that Hb is then **unavailable to carry oxygen** until the body slowly clears it (hours). A heavy smoker effectively walks around with **permanent low-grade anemic hypoxia (Type b)**. This is why the smoker's hypoxia threshold drops 3,000 ft.

Smoker vs Non-Smoker — Altitude Ceiling Comparison



One pack of cigarettes a day permanently shaves 5–8 % off the pilot's effective O₂-carrying capacity, and drops the hypoxia threshold from 10,000 ft to roughly 7,000 ft — a 3,000-ft penalty.

13.3 The Full Medical-Impact List

DGCA-quoted health effects on a smoking pilot

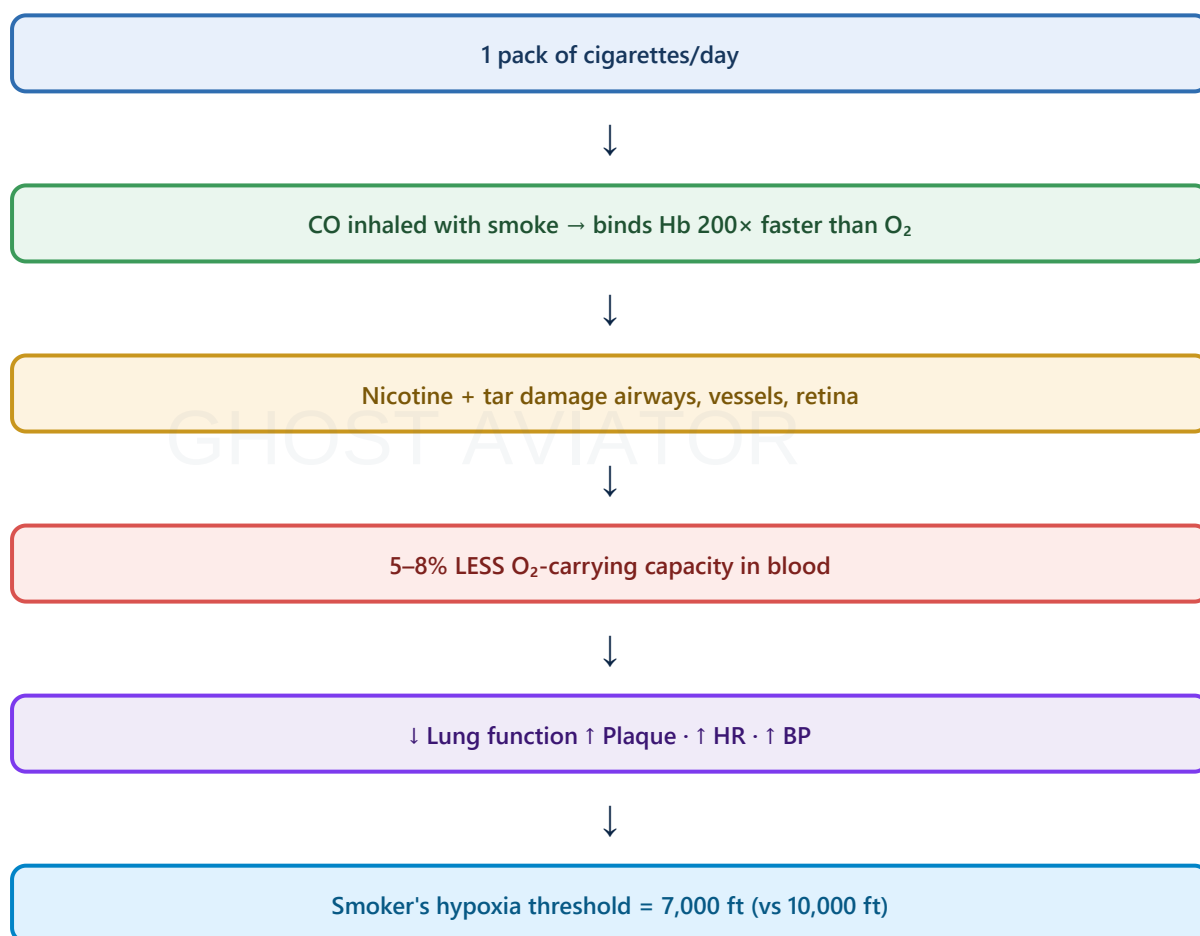
The smoker pilot is exposed to **all six** of the following — every one with direct flight-safety implications:



- **Lung cancer**
- **Breathing problems**
- **Circulatory problems**
- **Reduced tolerance to G forces**
- **Increased risk of heart attack**
- **Degradation of night vision**

Smoking — what it breaks and why it matters in the cockpit

Health Effect	Flight-Safety Implication
Lung cancer	Eventual respiratory failure — medical disqualification.
Breathing problems (COPD, chronic bronchitis)	Reduced ventilation → reduced O ₂ uptake → lowered hypoxia threshold (the 7,000-ft figure above).
Circulatory problems	Plaque, atherosclerosis, peripheral vascular disease → narrower arteries → ischemic hypoxia risk (§10.3c).
Reduced tolerance to G forces	Critical in aerobatics, fighter pilots, upset recovery. Less G-tolerance → earlier G-LOC.
Increased risk of heart attack	Direct link to angina/MI risk-factor list in §9.5 (smoking was one of the 12 listed).
Degradation of night vision	Recall night vision is impaired at 5,000 ft for non-smokers (§10.5). Smokers see degradation at <i>even lower altitudes</i> — devastating for night IFR and night VFR ops.



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Practical CRM note



DGCA Class-1 / Class-2 medicals do *not* automatically disqualify a smoker, but the lifestyle is flagged. **If you smoke and you are reading this, you are accepting a permanent flight-performance handicap.** Even one cigarette before takeoff materially lowers your hypoxia threshold for that sortie. Best practice for examined fitness: **do not smoke at all, especially in the 24 hours before flight.**

§ 14

Alcohol

The headline — alcohol is a depressant



Alcohol acts primarily as a depressant. Do not fly while under the influence of alcohol. **Even small amounts of alcohol in the system can adversely affect judgment and decision-making abilities.**

14.1 The 24-Hour Bottle-to-Throttle Rule

The hard rule — memorise verbatim

An excellent rule is to allow **TWENTY-FOUR HOURS** between the last drink and takeoff time.



This is the "24-hour bottle-to-throttle" rule. It is more conservative than the statutory minimum in some jurisdictions (often 8 hours), and is the answer DGCA expects in the HPL paper. Some operators enforce 12 hours; some, 24. The DGCA reference textbook recommends **24 hours**.

14.2 Alcohol Metabolism — The Fixed Rate

DGCA-quoted metabolism rate

Remember that your body metabolises alcohol at a **fixed rate**, and **no amount of coffee or medication will alter this rate**. Alcohol leaves the body at an average rate of



0.015 g/100 mL/hour, which is the same as reducing your **Blood Alcohol Content (BAC)** level by **0.015 per hour**.

For men, this is usually a rate of about ONE STANDARD DRINK PER HOUR.

24_{hr} Bottle-to-throttle separation

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0.015 g/100 mL/hr metabolism rate ($\approx$ 1 drink/hr in men)

40mg% BAC at which pilot errors spike significantly

14.3 Altitude Amplifies the Effect — "1 = 2" Rule

The "one drink at altitude equals two at sea level" rule



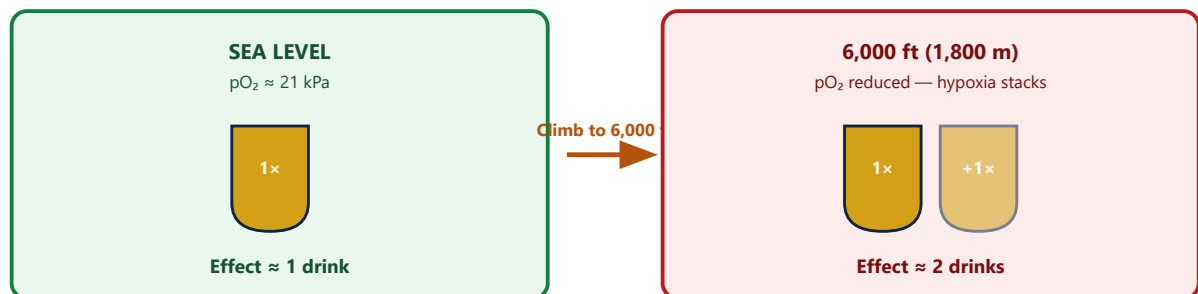
Relatively small amounts of alcohol **significantly decrease a pilot's tolerance to hypoxia (oxygen lack)**. At **6,000 ft (1,800 m)**, the effect of **ONE** drink is that of **TWO** drinks at sea level. Even at sea level alcohol impairs judgment and reaction time. **Therefore, alcohol and flying do not mix.**

Why? — histotoxic + hypoxic stacking



Recall **Histotoxic Hypoxia (§10.3d)**: high blood alcohol levels prevent cells from *using* the oxygen they receive. Layer that on top of **Hypoxic Hypoxia (§10.3a)** from altitude, and you have two oxygen-starvation mechanisms operating *at the same time*. They are **additive** — exactly the same principle that makes a smoker's hypoxia worse at altitude.

Same drink — very different effect at altitude



One drink at 6,000 ft hits the pilot like two drinks at sea level. Hypoxic + Histotoxic Hypoxia stack.

14.4 Recommended Maximum Alcohol Intake — Units & Rules

Definition of "one unit"



ONE UNIT of alcohol = half a pint of beer = a standard glass of wine = one measure of spirits.

MEN

5 units / day · 21 units / week

Maximum recommended consumption.

WOMEN

3 units / day · 14 units / week

Maximum recommended consumption.

1 UNIT EQUALS

½ pint beer

1 UNIT EQUALS

1 glass wine

1 UNIT EQUALS

1 measure spirits

MEN – DAILY/WEEKLY

5 / 21

WOMEN – DAILY/WEEKLY

3 / 14

14.5 BAC 40 mg/100 ml — The Pilot Error-Spike Threshold

DGCA-quoted: the BAC level at which errors balloon

Blood alcohol concentrations of **40 mgs per 100 ml** results in significant increases in errors committed by pilots due to the following effects:

- Impaired judgment and impaired ability to reason
- Degraded muscular coordination and degraded vision
- Lack of inhibitions and self-control
- Increased susceptibility to Hypoxia
- Damages to the liver, heart, brain and blood cells
- Affects short and long-term memory
- Slows reaction time
- Sufferer may feel that performance is improved (*the alcohol-euphoria trap*)
- Balance and sensory illusions
- Irregular sleep patterns



The euphoria trap — analogous to hypoxia



"**Sufferer may feel that performance is improved**" is the alcohol equivalent of *hypoxia's euphoria* (§10.2). The pilot is the *least* qualified person in the cockpit to judge whether he's safe to fly. This is precisely why **fixed bottle-to-throttle rules exist** — they take the judgement out of the impaired pilot's hands.

14.6 Hangover & the "Masked Hangover" Warning

DGCA-quoted hangover rule — verbatim



Do not fly with a hangover, or a "masked hangover" (symptoms suppressed by aspirin, caffeine or other medication). High altitude, where oxygen is deficient, aggravates these effects.

Why a "masked" hangover is worse than an obvious one



A normal hangover at least gives you a warning sign — you feel awful, you don't fly. A **masked hangover**, where caffeine, paracetamol, ibuprofen or other OTC medication has suppressed the headache and nausea, leaves you **still impaired** in judgement, coordination, vision and reaction time — but **without the warning**. Several aviation accidents have been traced to a pilot who took an aspirin, "felt fine," and flew with substantial residual BAC.

Last drink BAC peak



BAC drops by 0.015



BAC $\approx$ 0 SAFE to fly

§ 15

Blood Pressure

15.1 What Determines Blood Pressure

The four determinants — DGCA-quoted

Blood pressure depends on:



- The **cardiac output**,
- The **resistance of the capillaries** (peripheral resistance),
- The **elasticity of the arterial walls**, and
- The **blood volume and viscosity**.

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15.2 Definitions — pressure on the arteries

Three key facts



- **Blood pressure is the pressure exerted by blood on the walls of the main arteries.**
- The blood-pressure which is measured during flight medical checks is the **pressure in the artery of the upper arm** (representing the pressure at heart level).
- The **permanent pressure against the arterial wall is called DIASTOLIC pressure.**
- The **increased pressure occurring with each beat of the heart is called the SYSTOLIC pressure.**

SYSTOLIC PRESSURE

The **increased pressure occurring with each beat of the heart.**

This is the higher number in the BP reading — generated during ventricular contraction (*systole*, §9.2). It is the pressure peak as blood is ejected from the left ventricle into the aorta.

DIASTOLIC PRESSURE

The **permanent pressure against the arterial wall.**

This is the lower number — the resting pressure between heartbeats, when the heart muscle relaxes (*diastole*) and refills with blood. It represents the baseline strain on the arteries.

15.3 120/80 — the Normal Benchmark

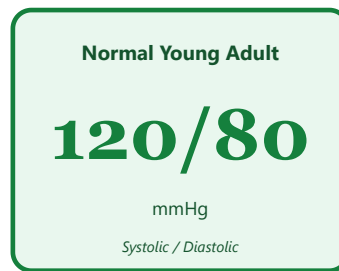
The number every pilot must know



120/80 is a normal blood pressure for a healthy young adult.

The notation reads "120 over 80" — meaning **systolic 120 mmHg, diastolic 80 mmHg**. This is the figure that DGCA aero-medical examiners measure against at every Class-1 and Class-2 medical.

Reading a Blood-Pressure Cuff — 120 / 80



Definitions

SYSTOLIC (120)

↑ pressure with each heartbeat

DIASTOLIC (80)

Permanent pressure against artery wall

Measured in upper-arm artery

The BP cuff inflates around the upper arm, then deflates while the examiner listens for arterial sounds. Two numbers — systolic peak with each beat, diastolic resting pressure between beats.

15.4 High Blood Pressure (Hypertension) — Causes & Pilot Implications

DGCA-quoted — the unfitness clause

High blood pressure or hypertension is a **MAJOR CAUSE** of unfitness in pilots.

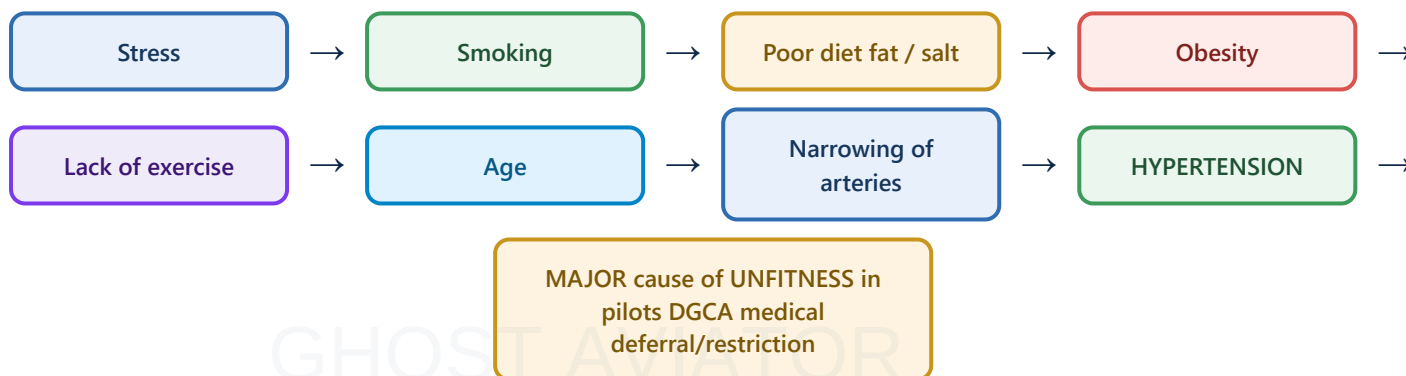


This single sentence is the most important takeaway from §15. The DGCA aero-medical examiner will **defer or restrict** a pilot's medical certificate the moment hypertension is detected and not adequately controlled.

Causes of Blood Pressure (Hypertension) — full DGCA list

Seven causes of hypertension a pilot must remember

#	Cause	Pilot-Specific Note
1	Stress	Sustained ANS / adrenaline activation. Pilots are exposed to chronic occupational stress — duty rosters, weather, currency requirements.
2	Smoking	Direct link to §13. Nicotine constricts vessels; CO damages endothelium.
3	Poor diet (excess fat or salt)	Salt → fluid retention → ↑ blood volume. Fat → plaque → ↑ peripheral resistance.
4	Obesity	Greater body mass requires more cardiac output; metabolic syndrome adds insulin resistance.
5	Lack of exercise	Deconditioned heart, stiffer vessels, higher resting BP.
6	Age	Arterial elasticity falls with age (recall §9.5 risk-factor list). Non-modifiable.
7	Narrowing of the arteries	Atherosclerosis — plaque-narrowed vessels create higher peripheral resistance. Same plaque that causes angina/MI.



What a pilot can do — the modifiables



Of the seven causes, **five are modifiable** (stress management, no smoking, low-salt/low-fat diet, weight control, regular exercise). Only **age** and (to a large extent) **narrowing of arteries from existing plaque** are non-modifiable. **The pilot who fails his Class-1 medical because of hypertension has lost his career to a condition that was, in most cases, preventable.**

Cross-links — see also

- **§9.1 / 9.2:** cardiac output = $HR \times \text{stroke volume}$ — directly drives systolic pressure.
- **§9.5:** hypertension is one of the 12 risk factors for angina / heart attack.
- **§13.3:** smoking causes circulatory problems and accelerates plaque.
- **§14.5:** alcohol contributes to liver/heart/brain damage.



The DGCA HPL paper frequently *combines* these topics in one MCQ stem — e.g. "A 48-year-old smoker with BP 145/95 ..." — testing whether you can connect the dots.

§ R4

Self-Check, Cheat-Sheet & Mnemonics

GHOST AVIATOR

GHOST AVIATOR

— Part 4

Master cheat-sheet — Part 4 numbers

Every numeric / regulatory fact from Part 4

Parameter	Exact Value	Where
Smoker's effective hypoxia altitude (vs non-smoker 10,000 ft)	7,000 ft	\$13.1
O ₂ -capacity reduction — 1 packet of cigarettes/day	5 - 8 %	\$13.2
Number of medical effects of smoking listed by DGCA	6	\$13.3
Bottle-to-throttle rule	24 hours	\$14.1
Alcohol metabolism rate	0.015 g/100 ml/hr	\$14.2
Approximate male metabolism rate	≈ 1 standard drink / hr	\$14.2
"1 = 2" altitude	6,000 ft (1,800 m)	\$14.3
1 unit of alcohol equals	½ pint beer / 1 glass wine / 1 spirit measure	\$14.4
Men — daily / weekly maximum	5 / 21 units	\$14.4
Women — daily / weekly maximum	3 / 14 units	\$14.4
BAC at which pilot errors spike	40 mg/100 ml	\$14.5
Normal BP for healthy young adult	120 / 80 mmHg	\$15.3
Site of BP measurement at medical	Upper-arm artery	\$15.2
Number of listed causes of hypertension	7	\$15.4

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DGCA-style probe questions

Try these without looking back

1. State the effective hypoxia altitude for a smoker vs a non-smoker. What is the size of the penalty in feet?
2. By what percentage does a one-pack-per-day smoker reduce his oxygen-carrying capacity?
3. List the SIX medical effects of smoking on a pilot, as quoted in DGCA syllabus.
4. State the recommended bottle-to-throttle separation.
5. What is the body's metabolism rate for alcohol? Can coffee or medication speed it up?
6. At what altitude does one drink have the effect of two at sea level? Why?
7. Define "one unit" of alcohol. State the daily and weekly maxima for men and women.
8. At what blood alcohol concentration do pilot errors spike significantly? List four effects at this level.
-  9. What is a "masked hangover" and why is it especially dangerous?
10. State the four factors that determine blood pressure.
11. Define *systolic* and *diastolic* pressure. Which is higher? Which represents the "permanent pressure on the arterial wall"?
12. State the normal BP for a healthy young adult. Where is BP measured at the medical?
13. List the seven causes of hypertension. Which are modifiable?
14. Why is hypertension described as "a major cause of unfitness in pilots"?
15. How does smoking link directly to the angina/heart-attack risk-factor list from §9.5?
16. Why does a smoker have a lowered night-vision capability?
17. Explain why the "1 = 2" rule for alcohol at altitude makes physiological sense — name the two types of hypoxia involved.

Mnemonics — burn these into long-term memory

MNEMONIC — SMOKING EFFECTS ON PILOT "LBCRID" = Lung cancer · Breathing problems · Circulatory problems · Reduced G-tolerance · Increased heart-attack risk · Degraded night vision.
"Lighting Burns Cells; Risks Increase Daily".

MNEMONIC — THE SMOKER'S PENALTY "Smoker = minus 3,000." A smoker hits hypoxia 3,000 ft lower than a non-smoker (7,000 vs 10,000 ft).

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MNEMONIC — BOTTLE-TO-THROTTLE **"24 hours, full stop."** Forget the 8-hour minima — DGCA wants 24.

MNEMONIC — ALCOHOL METABOLISM **"15 / 100 / 60."** 0.015 g per 100 ml per hour ($\approx$ 1 drink/hour in men). The body works on a fixed clock — no coffee shortcut.

MNEMONIC — ALCOHOL UNITS **Men 5/21 · Women 3/14.** Daily / weekly. The "21" and "14" are equal to $(5 \times 4) + 1$ and roughly $(3 \times 4) + 2$ — but just memorise.

MNEMONIC — "1 = 2" **"Six grand — drinks double."** At 6,000 ft, one drink = two at sea level (because hypoxic + histotoxic hypoxia stack).

MNEMONIC — BP NORMAL **"One twenty over eighty."** Higher number = systolic (with each beat). Lower number = diastolic (between beats / "permanent" pressure).

MNEMONIC — HYPERTENSION CAUSES **"SS PO LAN"** = **S**tress · **S**moking · **P**oor diet · **O**besity · **L**ack of exercise · **A**ge · **N**arrowing of arteries.

MNEMONIC — DIASTOLIC VS SYSTOLIC **"D = Default. S = Spike."** Diastolic = default/baseline/resting pressure. Systolic = spike with each heartbeat. *Or:* "D for Down number; S for Spike number."

MNEMONIC — BP DETERMINANTS **"COVE"** = **C**ardiac output · **O**bstruction (peripheral resistance) · **V**olume + viscosity · **E**lasticity of arteries.

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Human Factors

Part 5 of the master study set — Baroreceptor Reflex · Blood Donation · Cabin Pressurization · Time of Useful Consciousness (TUC) · Decompression & the Bends · Flying after Diving

CHAPTER

Chapter 26 (the DGCA reference textbook)

INSTRUCTOR

Ghost Aviator

EXAM

DGCA CPL / ATPL — HPL

SECTION

5 of N — Pressure, TUC & the Bends

Why Part 5 may be the most heavily tested block for jet/transport aspirants

The **Time of Useful Consciousness (TUC) table**, **cabin pressurization**, **decompression sickness**, and **flying-after-diving 24-hour rule** sit at the heart of every operational HPL stem question. Get the TUC numbers wrong by a few seconds and you've lost the question — and in a real rapid decompression, you've lost the aircraft.



This part also opens with two short topics easily missed by students: **the baroreceptor reflex** (how your body keeps BP steady when you stand up, get scared, or accelerate) and **blood donation** (with its specific 48-hour rule for active pilots).

Contents – Part 5

1. §16 Baroreceptor Reflex
2. §17 Donating Blood — the 48-hr rule
3. §18 Cabin Pressurization & TUC
4. — What TUC / EPT is
5. — Why TUC drops sharply at altitude
6. — TUC Master Table (verbatim)
7. — Rapid decompression halves TUC
8. §19 Decompression — Theory
9. — Definition & 8,000 ft max-comfort rule
10. — Pressure-halved at 18,000 ft
11. — Bends physiology — nitrogen bubbles
12. — Rapid vs Slow Decompression — recognition
13. — Tendency-increasing factors
14. §20 Decompression Sickness (DCS)
15. — Henry's Law revisited
16. — Effects of Nitrogen Bubbles — Bends, Creeps, Chokes, Stagers
17. — Treatment
18. — "12-hr no-fly after rapid decompression" rule
19. §21 Flying After Diving — the 24-hour rule
20. Self-Check, Cheat-Sheet & Mnemonics

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What it is



The baroreceptor reflex is the body's **automatic blood-pressure regulator**. Any change in your body's **demand for blood** can **trigger your baroreceptor reflex**. Specialised pressure-sensors ("baroreceptors") in the carotid arteries and aortic arch detect changes in BP and signal the brain to adjust heart rate and vessel diameter accordingly.

16.1 When the reflex fires — DGCA examples

For example, your body may need to adjust your blood pressure when you:

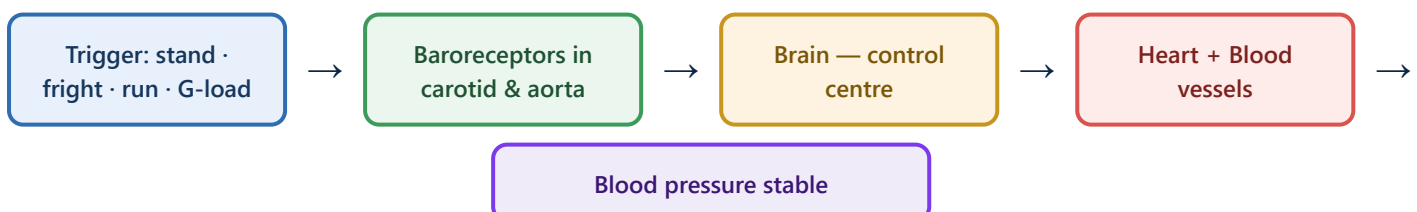
- **Change your body position, such as when you stand.**
- **See or experience something that frightens you.**
- **Switch from walking to running.**

Cockpit relevance



- **Postural changes:** standing up from a long sit (e.g. after a long flight, in turbulence, or after a low-blood-sugar moment) can cause transient hypotension → light-headedness. The baroreceptor reflex normally corrects this in 1–2 seconds.
- **Sudden fright / startle response:** pulls in adrenaline from the ANS (§7.4), spiking HR and BP. The baroreceptor reflex moderates this so you don't pass out from a hypertensive crisis.
- **Exercise & G-load:** from steady cruise to sudden manoeuvring, blood demand changes rapidly. The reflex keeps cerebral perfusion stable so you don't grey out.

A **well-conditioned, well-rested, well-hydrated** pilot has a sharper, faster baroreceptor reflex. A dehydrated or fatigued pilot's reflex is sluggish — which is one of several reasons hydration matters in long sectors and high-G ops.



Donating Blood — the 48-hr rule

DGCA-quoted



In a **completely healthy individual**, the fluid reduction caused by donating **one unit of blood** is replaced within **several hours**. In some people, however, the loss of blood causes **disturbances to the circulation that may last for several days**.

While the effects at **ground level are minimal**, **flying during this period may entail a risk**.

The DGCA rule — exact phrasing



Generally, active pilots should **NOT** donate blood, but if blood has been donated, they should wait at **LEAST 48 hours** before flying.

RECOMMENDED FOR ACTIVE
PILOTS

DO NOT donate

IF DONATION HAS OCCURRED

Wait $\geq$ 48 hr

REASON

**Circulatory
disturbance**

GROUND-LEVEL EFFECT

Minimal

Why blood donation interacts dangerously with flight

A single unit of blood (~450 ml) represents about **9 % of total blood volume** in an average adult.



While the plasma volume is restored in hours, the **red blood cell mass** takes weeks to fully recover. Reduced RBC mass = reduced haemoglobin = reduced oxygen-carrying capacity = **anemic hypoxia (§10.3b)**. Add altitude (hypoxic hypoxia, §10.3a) and the two stack — exactly the same principle as smoker-at-altitude and alcohol-at-altitude in Part 4.

Cabin Pressurization & Time of Useful

Consciousness (TUC)

18.1 What TUC / EPT is

Definition — memorise verbatim

Time of useful consciousness (TUC), also **effective performance time (EPT)**, is defined as the amount of time an individual is able to function effectively (e.g., perform flying duties) in an environment of inadequate oxygen supply.



It is the **period of time from the interruption of the oxygen supply** or exposure to an oxygen-poor environment **to the time when useful function is lost**, and the individual is **no longer capable of taking proper corrective and protective action**.

Critical concept — TUC is NOT time to unconsciousness



TUC is the time during which a pilot can still **do useful work** — don a mask, push a checklist, initiate descent. After TUC ends, the pilot may still be conscious for several more seconds, but is no longer **functional**. *This distinction is precisely why the DGCA emphasises "corrective and protective action" — the mask must be on the face before TUC expires.*

18.2 Why TUC Drops Sharply at Altitude

DGCA-quoted

At the higher altitudes, the **TUC becomes very short**; considering this danger, the emphasis is on **PREVENTION** rather than **CURE**.



Cabin pressurization eliminates many problems associated with high altitude flying, but it introduces other potential problems, the most important being the **risk of rapid decompression**.

What determines TUC after a rapid decompression

The time of useful consciousness (TUC) following a rapid decompression depends on:



1. **Aircraft altitude,**
2. **The rate at which pressure falls, and**
3. **The level of physical activity of the individual at the time of the event.**

Jet-transport TUC reference values

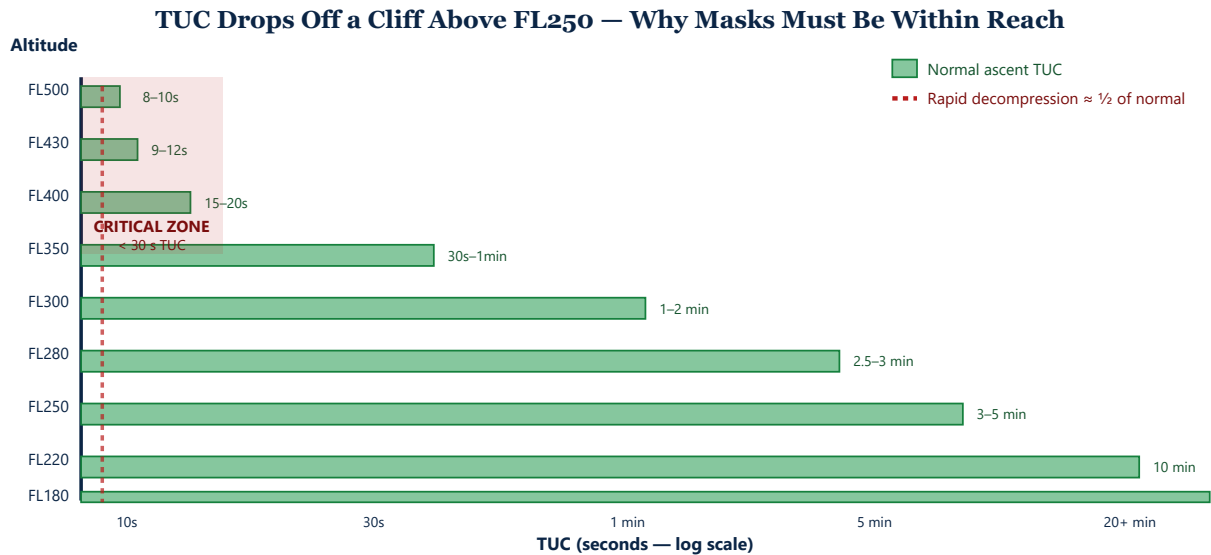
- At **typical jet transport aircraft altitudes (35,000 feet)** TUC will vary between **33 and 54 seconds**.
-  Those average values can be expected to **drop by HALF at 40,000 feet**.
- This emphasizes the importance of **immediate availability of supplemental oxygen to crew members**.
- RAPID DECOMPRESSION CAN REDUCE TUC BY HALF.**

18.3 TUC Master Table — Verbatim

This is the table you must memorise — both columns. Every DGCA HPL question on TUC is drawn from these figures.

Time of Useful Consciousness (TUC) by Altitude — DGCA Reference

Altitude (measured barometrically)	TUC (normal ascent)	TUC (rapid decompression)
FL180 (18,000 ft; 5,500 m)	20 to 30 minutes	10 to 15 minutes
FL220 (22,000 ft; 6,700 m)	10 minutes	5 minutes
FL250 (25,000 ft; 7,600 m)	3 to 5 minutes	1.5 to 3.5 minutes
FL280 (28,000 ft; 8,550 m)	2.5 to 3 minutes	1.25 to 1.5 minutes
FL300 (30,000 ft; 9,150 m)	1 to 2 minutes	30 to 60 seconds
FL350 (35,000 ft; 10,650 m)	30 seconds to 1 minute	15 to 30 seconds
FL400 (40,000 ft; 12,200 m)	15 to 20 seconds	7 to 10 seconds
FL430 (43,000 ft; 13,100 m)	9 to 12 seconds	5 to 6 seconds
FL500 (50,000 ft; 15,250 m)	8 to 10 seconds	5 seconds



Above FL250 the TUC clock starts collapsing rapidly. By FL400 it is under 20 seconds in normal flight — about 7 seconds after a rapid decompression.

18.4 Rapid Decompression Halves TUC

The "halving rule" — DGCA-quoted

"Rapid decompression can reduce TUC by half."



Why? Because a rapid decompression doesn't just drop the pilot to ambient pressure — it actually **sucks oxygen out of the lungs into the cabin atmosphere** (Henry's law, in reverse). The pilot is left with **less oxygen in the bloodstream than the new ambient pressure alone would predict**.

33–54s TUC at FL350 (normal ascent)

1/2 Reduction after rapid decompression

7–10s TUC at FL400 (rapid decompression)

Operational pilot response — the drill

After a rapid decompression in a transport jet you have **seconds, not minutes**:



1. **Don oxygen masks** immediately — quick-don, regulator to EMERGENCY/100 %.
2. **Establish crew communication.**
3. **Initiate emergency descent** — target **10,000 ft** or MSA, whichever higher.
4. **Squawk 7700**, declare MAYDAY.

This drill is muscle-memory in transport flight training precisely because there is no time to think it through at FL350+.

§ 19

Decompression — Theory



Definition

"Decompression" means the lowering of pressure.

19.1 The 8,000 ft "Maximum Comfort" Rule

DGCA-quoted



The maximum altitude without oxygen at which flying efficiency is not impaired is

8,000 feet.



DGCA-quoted — flight risk below 10,000 ft

When flying at altitude below 10,000 feet, the risk of suffering from conditions related to decompression is low.

19.2 Atmospheric Pressure is Halved at 18,000 ft

Nitrogen saturation & pressure facts



- At ground level, the body tissues are **saturated with nitrogen**, the inert gas which makes up **80 % of our atmosphere**.
- As the aircraft climbs, atmospheric pressure is reduced.
- By **18,000 ft ASL (5,486 m)** atmospheric pressure is **HALVED**.
- **Decompression sickness symptoms may develop at 18,000 ft and above.**
- Pilots flying aircraft with **unpressurised cabins at altitudes greater than 25,000 feet ASL (7,620 m)** may be subject to "the bends".

19.3 The Bends — Physiology of Nitrogen Bubbles

The bottle-of-soda mechanism — DGCA's own analogy

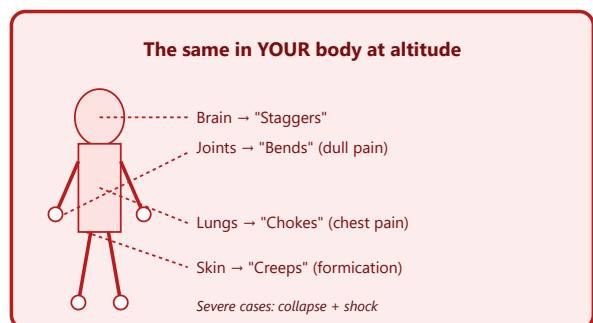
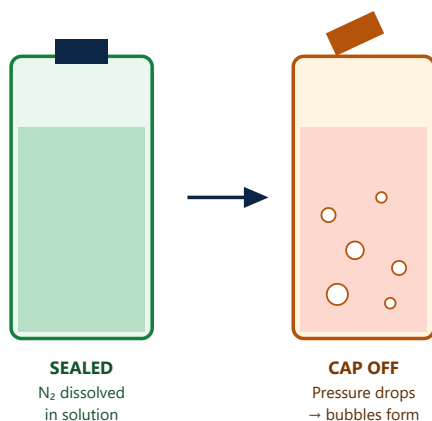
"The bends" condition is caused by **bubbles of nitrogen forming in the tissues because the ambient (atmospheric) pressure is less than the pressure at ground level.** (An example of this phenomenon is the **bubbles formed when a bottle of soda pop is opened**, and the pressure is reduced.)



The bubbles may:

- **Track into joint spaces** causing a **dull, sickening pain**.
- **More dangerously** they may be **released into the lungs or the brain**, giving rise to **chest pain and/or collapse**.

The Soda-Bottle Analogy — Why Pressure Drop = Bubbles



Join live classes for guided practice and doubt clearing.

When pressure falls (climb above ~18,000 ft, or rapid decompression), dissolved N_2 comes out of solution in the body just as CO_2 does when a soda bottle is opened.

19.4 Cabin Pressurization & Rapid vs Slow Decompression

How airline cabins solve the problem



Airlines and high-performance aircraft have cabin pressurization systems to maintain an artificially "low altitude" within the cabin or cockpit. The pressurization of a commercial airliner flying at 30,000 ft maintains an internal cabin pressure equivalent to about 6,000 ft, with a maximum pressure of 8,000 ft.

FAST (Rapid) Decompression

A fast decompression is recognizable by:

- Mist in the cabin
- Blast towards the exterior of the aircraft
- Expansion of body gases
- Blast of air released violently from the lungs

SLOW Decompression

A slow decompression may be caused by:

- A slight air-tightness defect, or
- Bad functioning of the pressurization.

Insidious onset — no warning blast, no mist, but cabin altitude creeps up over minutes. Detected via the cabin-altitude warning horn (typically at ~10,000 ft cabin altitude in transport jets).

19.5 Factors that Increase the Tendency to Develop the Bends

Five DGCA-quoted predisposing factors

The tendency to develop the bends increases with:



1. High rates of climb,
2. Age,
3. Obesity,
4. Physical activity,
5. Low temperatures.

MAX ALTITUDE WITHOUT O₂ —
NO IMPAIRMENT
8,000 ft

LOW DCS RISK BELOW
10,000 ft

ATMOSPHERIC PRESSURE
HALVED AT
18,000 ft

UNPRESSURISED FLIGHT —
BENDS THRESHOLD
> 25,000 ft

TYPICAL AIRLINER CABIN
ALTITUDE
≈ 6,000 ft

MAXIMUM CABIN ALTITUDE
8,000 ft

N₂ % IN ATMOSPHERE
≈ 80 %

DCS RISK FACTORS COUNT
5

§ 20

Decompression Sickness (DCS)

DGCA-quoted introduction



Without a cabin pressurization system, pilots and passengers in high flying aircraft would be exposed to high altitude, like hypoxia, low temperatures and Decompression Sickness/Illness.

20.1 Henry's Law Revisited — the underlying physics

Henry's Law statement — verbatim from DGCA



Henry's Law explains the occurrence of decompression sickness. The principle that at a constant temperature the concentration of a gas dissolved in a fluid with which it does not combine chemically is almost directly proportional to the partial pressure of the gas at the surface of the fluid.

A rapid reduction in ambient pressure may cause the nitrogen in our blood to come out of solution as small bubbles leading to decompression sickness.

Symptom list & the "delayed onset" warning

Symptoms of decompression sickness are:



- Bends
- Chokes
- Skin manifestations
- Neurological symptoms
- Circulatory shock

Symptoms may appear several hours after the exposure.

20.2 Effects of Nitrogen Bubbles — Four Syndromes

The DGCA syllabus names **four specific syndromes** based on the tissue affected. Memorise the names and the body region.

Joints The BENDS

Joints: Bubbles in the joints cause **rheumatic-like pain**, called **the Bends**.

Classic shoulder & knee deep, dull ache — diver's bends, identical mechanism.

Skin The CREEPS

Skin: Nitrogen bubbles released under the skin cause **the Creeps**, a **sensation of movement under the skin**.

Linked to formication (§10.4) — the "ants crawling under the skin" feeling.

Respiratory System The CHOKES

Respiratory System: Shortness of breath and a feeling of burning, gnawing and piercing pain. Known as **the Chokes**.

Bubbles in pulmonary capillaries → ventilation/perfusion mismatch. Burning chest pain.

The Brain The STAGGERS

The Brain: Loss of mental functions and control of movement. Known as **the Staggers**.

Neurological DCS — confusion, ataxia, weakness, paralysis. Most dangerous form.

DCS Syndromes — quick-reference one-liner

Tissue	Syndrome Name	Symptom Type
Joints	The Bends	Rheumatic-like joint pain
Skin	The Creeps	Sensation of movement under skin
Respiratory System	The Chokes	Shortness of breath; burning, gnawing, piercing chest pain
The Brain	The Staggers	Loss of mental function & movement control

20.3 Treatment of Decompression Sickness

DGCA-quoted four-step treatment

- 
1. Keep patient warm and on 100 % Oxygen.
 2. An immediate descent must be initiated.
 3. Land as soon as possible.
 4. Seek medical assistance immediately on landing.

Suspect DCS — Bends · Creeps · Chokes · Staggers



1. Keep patient WARM + 100% Oxygen



2. Initiate IMMEDIATE DESCENT



Join live classes for guided practice and doubt clearing.

3. Land as soon as possible



4. Seek medical aid immediately Hyperbaric chamber may be needed

20.4 The 12-Hour No-Fly Rule After Rapid Decompression

DGCA-quoted



Do not fly for at least 12 hours after experiencing rapid decompression even though you may be feeling fit.

Why 12 hours?



DCS symptoms can be **delayed for several hours**. Feeling "fit" immediately after a decompression event does **not** mean nitrogen bubbles are not still forming or growing in tissues. The 12-hour pause allows the body to off-gas the residual nitrogen at normal pressure, much like a diver waiting before flying or driving up a mountain.

§ 21

Flying After Diving — the 24-hour rule

DGCA-quoted mechanism



Decompression sickness can occur when flying at low altitude in individuals who have been diving, using compressed air breathing apparatus shortly before flight at a depth of 30 feet or more.

The hard rule — memorise verbatim



As a general rule, individuals should NOT fly within 24 hours following diving and certainly not the same day.

30_{ft} Diving depth that creates DCS risk on flying

24_{hr} Minimum wait between diving & flight

15_{min} – 12_{hr} Symptom-onset window after surfacing

Why diving + flight is so dangerous — DGCA-quoted



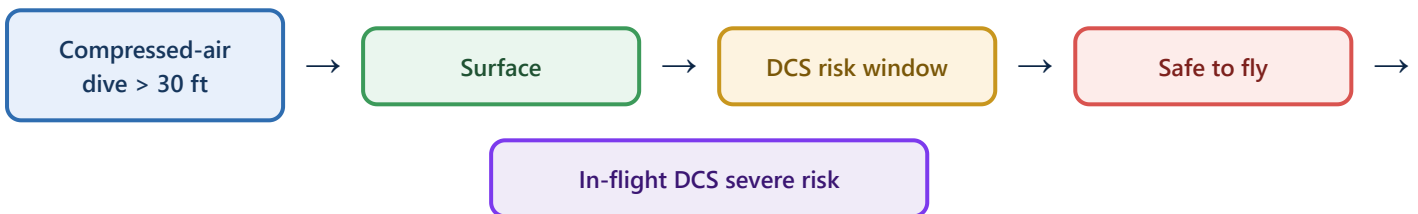
Occasionally a "medical emergency" arises as a result of compressed-air diving, when a diver is in danger of developing **air-embolism (bends) at the surface altitude**, as a result of being unable to decompress before surfacing. In some of these cases **air-evacuation is the only feasible method of getting the patient to a decompression chamber in time to treat this condition**. Flight, however, should be at **the lowest possible altitude to avoid aggravating the condition**.

Symptom onset timing — DGCA quote



Symptoms and signs **usually appear within 15 minutes to 12 hours after surfacing**; but in severe cases, symptoms may **appear before surfacing or immediately afterwards**. **Delayed occurrence of symptoms is rare** (the source text terminates mid-sentence at the page break — continued in §21+).

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Cross-link recap — the three "wait before flying" rules

You now have three numbers in your head that the DGCA examiner loves to swap around:

- **Alcohol — bottle to throttle:** 24 hr (§14.1)
- **Blood donation:** 48 hr (§17)
- **Flying after diving:** 24 hr (§21)
- **Flying after rapid decompression:** 12 hr (§20.4)



Do not mix them up. Diving and alcohol share the 24-hour figure; donation gets the longest pause; rapid decompression "only" 12 — but with mandatory medical clearance afterwards.

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§ R5

Self-Check, Cheat-Sheet & Mnemonics

— Part 5

Master cheat-sheet — Part 5 numbers

Every numeric / regulatory fact from Part 5

Parameter	Exact Value	Where
Number of DGCA-listed baroreceptor triggers	3	§16.1
Active-pilot blood donation rule	Don't donate; if done, wait 48 hr	§17
Max altitude without O ₂ , no efficiency loss	8,000 ft	§19.1
Low DCS risk altitude — below	10,000 ft	§19.1
Atmospheric pressure halved at	18,000 ft (5,486 m)	§19.2
DCS symptoms may develop at and above	18,000 ft	§19.2
Unpressurised flight bends threshold	> 25,000 ft (7,620 m)	§19.2
N ₂ % of atmosphere	80 %	§19.2
Typical airliner cabin altitude (30,000 ft cruise)	≈ 6,000 ft	§19.4
Maximum cabin altitude	8,000 ft	§19.4
TUC at FL180 (normal)	20–30 min	§18.3
TUC at FL220 (normal)	10 min	§18.3
TUC at FL250 (normal)	3–5 min	§18.3
TUC at FL280 (normal)	2.5–3 min	§18.3
TUC at FL300 (normal)	1–2 min	§18.3
TUC at FL350 (normal)	30 s – 1 min	§18.3
TUC at FL400 (normal)	15–20 s	§18.3

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Parameter	Exact Value	Where
TUC at FL430 (normal)	9–12 s	§18.3
TUC at FL500 (normal)	8–10 s	§18.3
TUC at FL350 rapid decompression	15–30 s	§18.3
TUC reduction by rapid decompression	$\frac{1}{2}$ (halved)	§18.4
TUC range at FL350 (jet typical)	33–54 s	§18.2
Number of factors that determine TUC after RD	3	§18.2
Number of factors that ↑ tendency to bends	5	§19.5
Number of named DCS symptoms (DGCA list)	5	§20.1
Number of named bubble syndromes	4 (B–C–C–S)	§20.2
DCS treatment steps	4	§20.3
No-fly after rapid decompression	≥ 12 hr	§20.4
Diving depth that triggers fly-risk	≥ 30 ft	§21
No-fly after diving	24 hr (not same day)	§21
DCS symptom onset window post-dive	15 min – 12 hr	§21

GHOST AVIATOR

DGCA-style probe questions

Try these without looking back

1. What is the baroreceptor reflex? Name three triggers.
2. State the DGCA recommendation for active pilots regarding blood donation. What is the minimum wait before flying?
3. Define Time of Useful Consciousness (TUC). What is its other name (acronym EPT)?
4. State three factors that determine TUC following a rapid decompression.
5. At FL350 in a transport jet, what is the typical TUC range during normal cruise?
6. By what factor does rapid decompression typically reduce TUC?
7. Reproduce the TUC table for FL220, FL280, FL350, and FL430 — both columns.
8. What is the maximum altitude without supplemental oxygen at which flying efficiency is not impaired?
9. At what altitude is atmospheric pressure halved? What is the inert gas making up 80 % of our atmosphere?
-  10. At what unpressurised flight altitude does the risk of the bends become significant?
11. State the typical cabin altitude maintained by a commercial airliner flying at FL300. What is the maximum cabin altitude?
12. Give four signs of a fast decompression. Give two causes of a slow decompression.
13. List the FIVE factors that increase the tendency to develop the bends.
14. State Henry's Law verbatim. How does it explain decompression sickness?
15. Name the FOUR DCS syndromes by tissue affected and their colloquial names.
16. State the four DGCA-quoted steps in the treatment of DCS.
17. How long after rapid decompression must a pilot wait before flying — even if feeling fit?
18. At what minimum diving depth does compressed-air diving create a fly-risk? How long must a diver wait before flying?
19. State the symptom-onset window for DCS after surfacing from a dive.
20. Compare and contrast the four "wait-before-flying" rules: alcohol, blood donation, diving, rapid decompression.

Mnemonics — burn these into long-term memory

MNEMONIC — BARORECEPTOR TRIGGERS "Stand-Scare-Sprint" = the three DGCA-listed triggers. Stand up, see something scary, switch from walking to running.

Join live classes for guided practice and doubt clearing.

MNEMONIC — WAIT-BEFORE-FLYING RULES

"12 - 24 - 24 - 48" = 12 hours after rapid decompression · 24 hours after the last drink · 24 hours after diving · 48 hours after blood donation.
Each step gets longer — easier to remember.

MNEMONIC — THE 4 DCS SYNDROMES (B-C-C-S)

"Bends · Creeps · Chokes · Staggers" in head-to-toe order from joints to brain. Or memorably: *"Joints Bend, Skin Creeps, Lungs Choke, Brain Staggers."*

MNEMONIC — DCS TREATMENT

"WODL-M" = **W**arm + 100% **O**xygen · **D**escend immediately · **L**and ASAP · **M**edical aid on landing.

MNEMONIC — BENDS PREDISPOSING FACTORS

"CAOP-T" = **C**limb rate · **A**ge · **O**besity · **P**hysical activity · **T**emperature (low). Or: *"Climb Aged-Obese Physical Cold"*.

MNEMONIC — TUC AT FL350 JET CRUISE

"Half a minute, half a minute, half a minute onward!" TUC at FL350 ≈ 30 s – 1 min normal; halved to 15–30 s on rapid decompression. *The mask must be on your face inside 10 seconds.*

MNEMONIC — SODA-BOTTLE PHYSICS

"Cap-off, bubbles-on." Open a soda → bubbles appear because pressure dropped. Same thing in your blood when cabin altitude rises past 18,000 ft. Henry's Law.

MNEMONIC — CABIN ALTITUDES

"6 normal · 8 max" = 6,000 ft typical cabin altitude · 8,000 ft maximum cabin altitude in commercial pressurised flight.

CPL · ATPL · Human Performance & Limitations Aviation Physiology &

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Human Factors

Part 6 of the master study set — Cockpit Environment (Humidity · Temperature · Vibration · Glare) · Incapacitation in Flight · Fits & Faints (Epilepsy & Syncope)

CHAPTER

Chapter 26 (the DGCA reference textbook)

INSTRUCTOR

Ghost Aviator

EXAM

DGCA CPL / ATPL — HPL

SECTION

6 of N — Environment & Incapacitation

Setting the scene — closing the loop on §21

Part 5 closed with the rule "*do not fly within 24 hours of diving*" — and a final line stating that "**delayed occurrence of symptoms is rare, but it does occur, especially if air travel follows diving.**" Part 6 now picks up where the source PDF continues, moving through the four **physical environment factors** that affect pilot performance in the cabin — **humidity, temperature, vibration, glare** — and then into the medically critical block of **Incapacitation in Flight** (obvious vs subtle) culminating in **Fits & Faints** (Epilepsy, Syncope).

This is the part most candidates underestimate. The **vibration-frequency table** and the "**absolute bar to flying licence**" sentence for epilepsy are direct one-line DGCA questions every year.

GHOST AVIATOR

Contents – Part 6

1. §22 Closing §21 — delayed DCS & flight after diving
2. §23 Humidity
3. — Normal vs uncomfortable RH ranges
4. — Aircraft humidifier systems
5. §24 Temperature
6. — DGCA's three reference temperatures
7. §25 Vibration
8. — Natural resonance of body parts
9. — Effects of vibration — full DGCA frequency table
10. §26 Glare & UV Radiation
11. §27 INCAPACITATION IN FLIGHT
12. — Why pilot incapacitation is a flight-safety issue
13. — Obvious Incapacitation
14. — Subtle / Insidious Incapacitation
15. — Obvious vs Subtle — why subtle is more dangerous
16. §28 Fits & Faints
17. — Epilepsy (Grand Mal · Petit Mal) — absolute bar
18. — Faint & Vasovagal Syncope
19. Self-Check, Cheat-Sheet & Mnemonics

§ 22

Closing §21 — Delayed DCS After Diving

Picking up the broken sentence

The Part-5 text ended with "*Delayed occurrence of symptoms is rare...*" — the rest of the sentence (Part 6 source PDF page 22) reads: "**...but it does occur, especially if air travel follows diving.**"



In plain English: **even if a diver feels perfectly fine 24+ hours after surfacing, a subsequent flight can re-precipitate DCS symptoms.** This is because residual nitrogen still dissolved in slow-perfused tissues (fat, bone marrow) can come out of solution when the pilot enters the lower cabin pressure of a transport flight. *The 24-hour rule is a minimum, not a guarantee.*

23.1 Why Humidity Matters Up High

DGCA-quoted



Humidity may become an issue with high-altitude jet transport aircraft because of the low relative humidity at their operational altitudes. The discomfort arising from low relative humidity may not imply physical indisposition.

DGCA-quoted humidity ranges



- **40 – 60 %** relative humidity is **NORMAL**.
- **< 20 %** may create **minor discomfort**, such as **skin, eye, nose, throat dryness**.

40–60% Normal relative humidity

< 20% Minor discomfort — skin, eye, nose, throat dryness

3–8% → 22% Modern humidifiers raise cabin RH from 3–8% to ~22%

Prevention & management



- **Overall dehydration can be prevented with adequate fluid intake.**
- **Diuretics like coffee or tea should be avoided.** They drive fluid out of the body via increased urination — the opposite of what is needed at altitude.

23.2 Aircraft Humidifier Systems

DGCA-quoted

The installation of humidifiers on aircraft **raises cabin/cockpit humidity**, but there are potential problems such as:

- **Weight penalty**,
- **Condensation**, and
- **Mineral contamination** that the designer must consider.

Aircraft such as the **Airbus A350, Boeing 787, and the future Boeing 777X** are compatible with onboard humidifiers, either in **crew areas or the entire cabin**. These technologies **increase humidity from 3–8 % to 22 %** and **reduce contaminants** in the air we breathe on a flight.

§ 24

Temperature



DGCA-quoted

Temperature affects performance as follows:

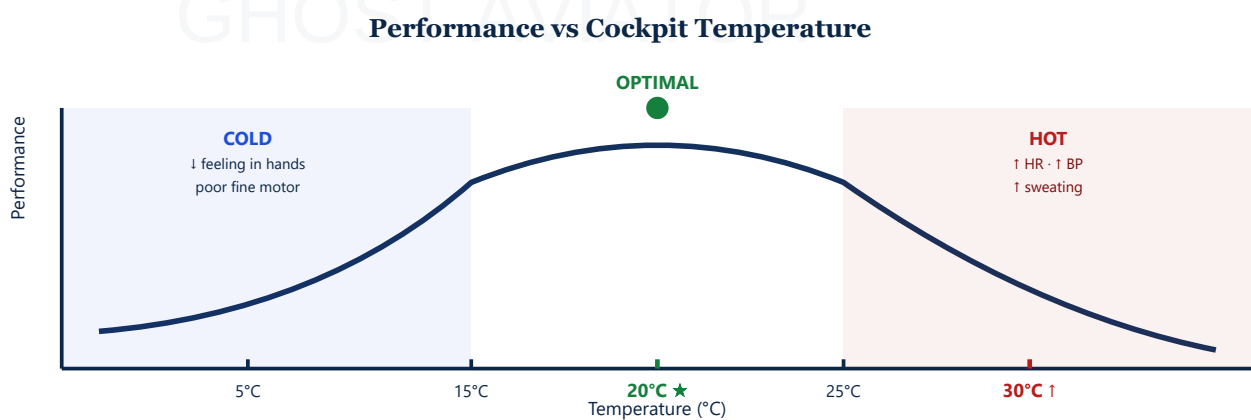
24.1 The Three Reference Temperatures — memorise verbatim

Temperature effects on pilot performance (DGCA verbatim)

Temperature	Effect on Performance
20 °C	Comfortable temperature for most people in normal clothing.
30 °C	Increased heart rate, blood pressure, and sweating.
> 15 °C	Discomfort, loss of feeling in hands, poor control of fine muscle movement. (Note: source phrasing uses "> 15 °C" — referring to deviations beyond 15 °C from a comfortable baseline, i.e. cold-stress.)

Cockpit-temperature considerations

- **At 20 °C** the pilot is comfortable — fine motor skills, judgement and reaction time are optimal.
- **At 30 °C** the body's ANS responds to heat stress by raising HR, BP and triggering sweating to cool the skin. Cognitive performance starts to degrade.
- **In cold conditions** — far below the comfort baseline — the pilot loses sensation in the fingers, struggles with fine-motor tasks like switch selection or fast checklist scanning, and may shiver involuntarily.
- For both extremes, **cabin temperature management is a flight-safety task**, not merely a comfort one. Climate control should be set to keep cockpit temperature near 20 °C for sustained operations.



Pilot performance peaks around 20 °C. Both cold (loss of feeling in hands, poor fine motor) and heat (↑ HR, ↑ BP, sweating) push performance off-peak.

§ 25

Vibration

25.1 Natural Resonance — Why Frequency Matters

DGCA-quoted opening

Different parts of the body show a natural resonance at different periods of vibration. For example:

- The **natural resonance of the eyeball is 30 – 40 Hz**, and
- The **skull is 1 – 4 Hz**.

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What "natural resonance" means in plain English



Every physical structure has a frequency at which it *wants* to vibrate — push it at that frequency and small inputs build up into huge oscillations (think of pushing a child on a swing in time with the swing's natural period). When external aircraft vibration matches a body part's resonant frequency, **that part suffers maximum disturbance**. The eyeball resonating at 30–40 Hz is precisely why **vision becomes blurred at certain helicopter or propeller-vibration frequencies**.

25.2 Effects of Vibration — Full DGCA Frequency Table



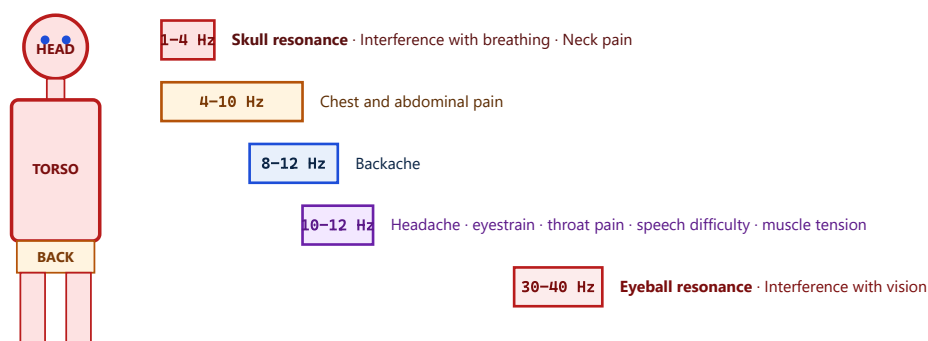
Memorise this table — direct exam target

Effects of vibration include:

Vibration frequency vs body effect (DGCA verbatim)

Frequency Range	Effect on the Body
1 – 4 Hz	Interference with breathing; neck pain. <i>(Skull resonance range.)</i>
4 – 10 Hz	Chest and abdominal pain.
8 – 12 Hz	Backache.
10 – 12 Hz	Headache, eyestrain, throat pain, speech difficulty, muscle tension.
30 – 40 Hz	Interference with vision. <i>(Eyeball resonance range.)</i>

Vibration Frequency → Body Region Affected



Match frequency = match the body part. Skull at 1–4 Hz · Eyeball at 30–40 Hz — both classic DGCA single-fact questions.

Join live classes for guided practice and doubt clearing.

Each frequency band corresponds to a specific body region. The two "natural resonance" frequencies — skull (1–4 Hz) and eyeball (30–40 Hz) — are the DGCA's favourite single-line MCQs.

Operational vibration sources in aviation

- **Helicopter rotors:** typically 4–7 Hz (main rotor) → chest/abdominal pain & backache range.
- **Piston / turboprop engines:** 10–30 Hz on the airframe → headache, eyestrain, vision interference.
- **Jet engine buffet:** higher-frequency, but resonant peaks in the seat may still strike critical body-part frequencies.
- **Turbulence:** low-frequency buffeting (1–10 Hz) → fits the skull / neck / chest range.

This is why aircraft seats incorporate **damping and isolation systems** — to keep the airframe's vibration spectrum from delivering energy at the worst body-resonance frequencies.

§ 26

Glare & UV Radiation



DGCA-quoted

UV radiation from sunlight can cause visual fatigue, as well as affect visual health.

Why glare and UV deserve their own section

At cruise altitudes (FL300+), the protective filtering of the atmosphere is reduced. Cockpit windows admit **significantly more UV-A and UV-B** than ground-level glass would. Over a long career, this contributes to:

- **Visual fatigue** — the immediate effect of glare on the working pilot. Squinting, eyestrain, reduced contrast sensitivity, headache.
- **Cumulative visual health damage** — cataract formation, macular degeneration risk, conjunctival/skin damage.

Practical pilot precautions

- Use **aviation-grade polarised or non-polarised UV-blocking sunglasses** (note: certain LCD instruments may distort under polarised lenses — check before adoption).
- Use **cockpit sun-visors** appropriately — don't leave them stowed when the sun is over the nose.
- For long-haul crews, schedule **vision rest breaks** on autopilot legs.
- Periodic **aero-medical eye examinations** — already mandated by DGCA — pick up early cataract / retinal changes.

§ 27

INCAPACITATION IN FLIGHT

27.1 Why Pilot Incapacitation is a Flight-Safety Issue

DGCA-quoted introduction — verbatim

The risk of seizure in flight is obvious. Incapacitation is in most cases:

- Sudden,
- Unpredictable,
- Unavoidable,
- Prolonged,
- Complete, and
- Potentially more frequent in the stressful flying environment,

... and constitutes a direct threat to the health and safety.

DGCA-quoted prevention measure

Periodical medical examinations minimize the risk of incapacitation in flight. The frequency of medical checks increases with advancing age.

CLASS-1 MEDICAL
(COMMERCIAL PILOT) UNDER
40
12 months

CLASS-1 MEDICAL, 40+
6 months

CLASS-2 MEDICAL (PPL) UNDER
40
5 years (varies)

CLASS-2 MEDICAL, 40+
2 years (varies)

(The DGCA medical-frequency periods are referenced in the syllabus generally and shown above for context; exact CAR / Schedule periods should be confirmed against the latest DGCA medical CAR / FAA Part 67 equivalent.)

27.2 Obvious Incapacitation

DGCA-quoted definition

Obvious incapacitation normally refers to a state in which **all of a crew member's physical or mental functions are lost**, including:



- **Loss of consciousness, OR**
 - **Being unable to move while retaining consciousness,**
- ... **rendering them completely unable to carry out their duties.**

Onset patterns & presentation



- Obvious incapacitation can sometimes involve **convulsions**,
- OR the victim may **lapse into unconsciousness several minutes after the incapacitation occurs.**

DGCA-quoted causes of obvious incapacitation



- **Cardiac arrest**
- **Myocardial infection** (*textual variant — "myocardial infarction" — heart attack*)
- **Interracial hemorrhage** (*intended: "intracranial haemorrhage" — bleed in the brain*)
- **Cerebral apoplexy** (*stroke*)
- **Epilepsy**

The source PDF uses the phrasings shown — students should be aware of the modern medical terminology in parentheses.

27.3 Subtle / Insidious Incapacitation

DGCA-quoted definition

SUBTLE (develops slowly and gradually), incapacitation refers to a state of a **partial or temporary loss of physical or mental function** which manifests itself in the form of:



- Partial paralysis,
- A dulling of perception, judgment, or responses or lack thereof,
- A state of absence of mind, distraction of attention,
- Trouble with speech,
- Inadequate responses,
- Meaningless utterances, etc.

The hidden-danger warning — DGCA verbatim



Particular attention must be paid to the fact that a crew member may become incapacitated **EVEN THOUGH THEIR APPEARANCE IS NO DIFFERENT FROM NORMAL.**

Possible causes of subtle incapacitation — DGCA list



- Temporary hypoglycemia (low blood sugar — pilot skipped meals)
- Reduction in blood pressure
- Cerebroopathy or psychopathy
- Excessive muscular fatigue
- Excessive drinking (see §14)
- Insufficient sleep
- Emotional instability
- Toothache
- Stomachache
- Headache

27.4 Obvious vs Subtle — Why Subtle is MORE Dangerous

DGCA-quoted — the counterintuitive truth



Since other crew members are often unable to detect subtle incapacitation quickly, from a flight safety point of view, it is possible that **SUBTLE INCAPACITATION MAY LEAD TO A SITUATION OF COMPARATIVELY GREATER DANGER THAN OBVIOUS INCAPACITATION.**

Why this matters in two-crew operations

With **obvious incapacitation**, the other crew member sees the captain slumped or convulsing, declares emergency, takes control, gets the aircraft on the ground. The hand-off is instant.



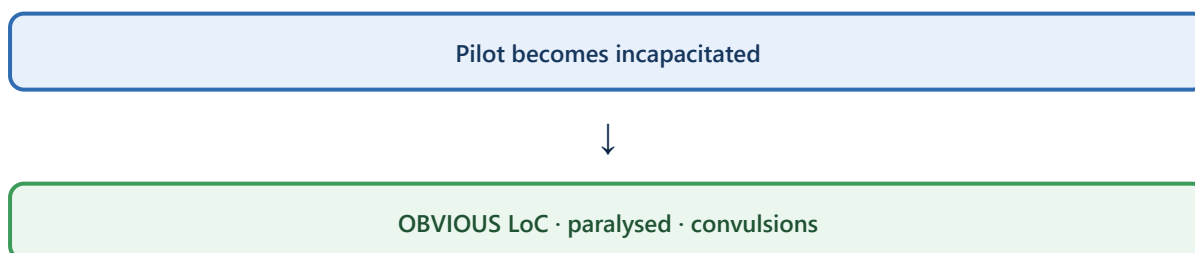
With **subtle incapacitation**, the captain is still moving switches, talking on the radio, even responding to questions — but his judgement is impaired. He may set the wrong altitude, mis-tune a NAV, mishear an ATC clearance, or fail to initiate a missed approach. The other pilot may not detect this until *after* the wrong outcome unfolds. This is the rationale behind **two-crew CRM**: a healthy independent cross-check that catches subtle drift before it becomes an accident.

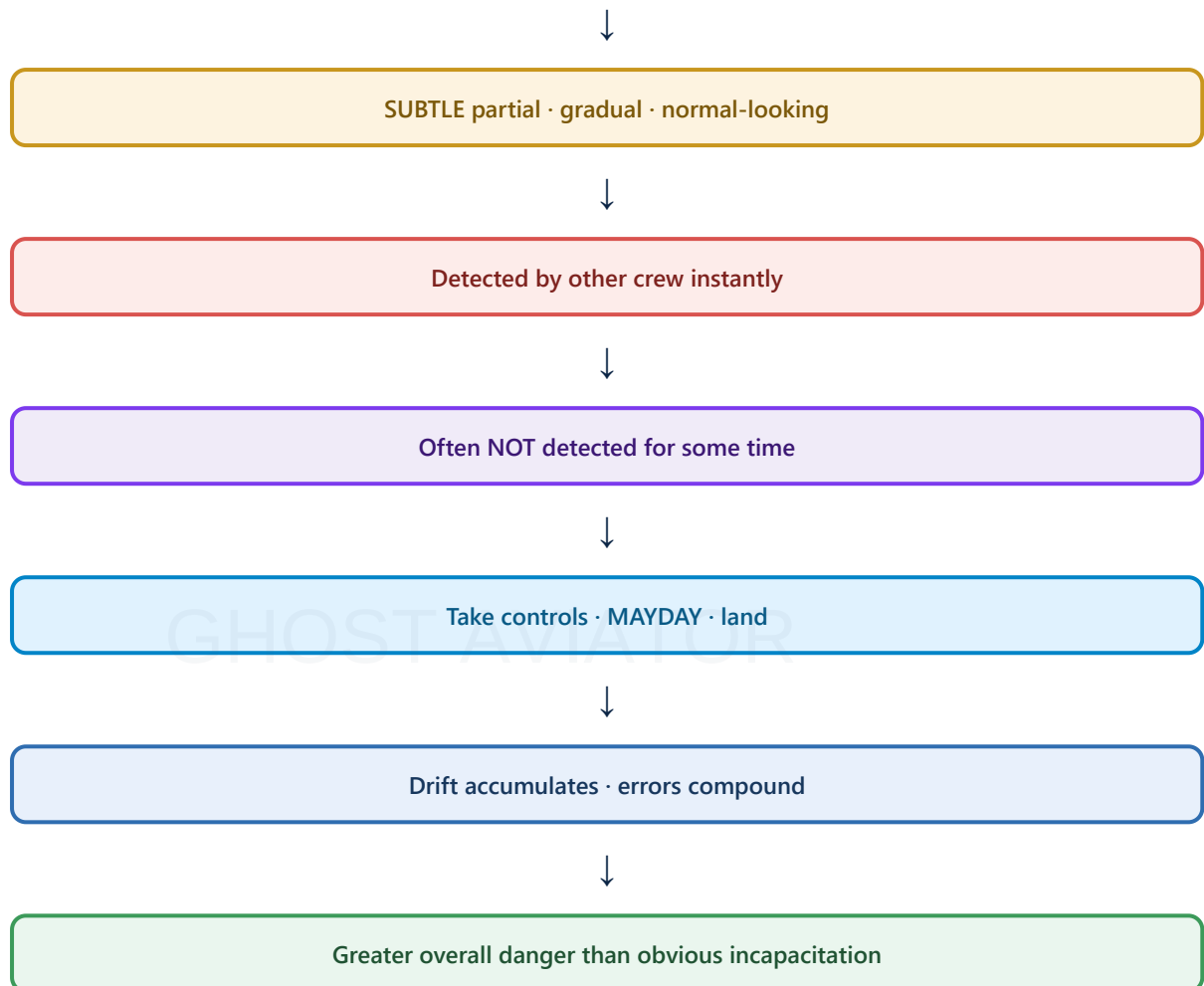
OBVIOUS Incapacitation

- **All functions lost** — LoC or paralysed-conscious
- May include convulsions / delayed LoC
- **Detected instantly** by the other crew
- Causes: cardiac arrest, MI, intracranial bleed, stroke, epilepsy
- **Handover happens fast**

SUBTLE Incapacitation

- **Partial or temporary** loss of function
- Appearance may be normal
- **Often undetected for some time** by the other crew
- Causes: hypoglycemia, ↓ BP, fatigue, sleep loss, drinking, emotional/dental/stomach/headache
- **Greater overall flight-safety danger**





§ 28

FITS & FAINTS

28.1 Epilepsy — Grand Mal & Petit Mal

DGCA-quoted definition



A **fit or seizure** is usually referred to as "**epilepsy**". A fit or a seizure is **not a specific disease** but a **set of signs or symptoms in response to a disturbance of the electrical activity in the brain**.

Grand Mal Epilepsy

- Manifests as a **generalized seizure**
- **Associated with a transient loss of consciousness**
- May be associated with a **prodromal phase** (*warning aura before the seizure*)
- Normally accompanied by **convulsions and uncontrolled physical movement**

Join live classes for guided practice and doubt clearing.

Petit Mal Epilepsy

- Also a **generalized seizure**
- **Not associated with a loss of consciousness**
- **Petit Mals are a MINOR attack**
- Often presents as brief "absence spells" — staring, blanking out for a few seconds

DGCA-quoted — the absolute bar



A seizure may or may not be associated with a loss of consciousness... **but ANY FIT, MAJOR OR MINOR, IS ASSOCIATED WITH AN UNPREDICTABLE LOSS OF CONSCIOUSNESS AND IS THEREFORE AN ABSOLUTE BAR TO THE HOLDING OF A FLYING LICENCE.**

Pilot-medical implication



This is one of the very few *absolute* medical disqualifications in aviation. Even controlled epilepsy on medication — even a single documented seizure event in adult life — is grounds for medical refusal. The reason is the word "**unpredictable**" — DGCA cannot certify the probability of an in-flight seizure as acceptably low.

28.2 Faint & Vasovagal Syncope

DGCA-quoted definition



Faint is a common cause of a loss of consciousness in adults. The most common causes of faints are:

Common causes of faint — DGCA verbatim list

#	Cause
1	Standing up quickly after prolonged sitting especially when hot or dehydrated
2	A sudden shock
3	Loss of blood after an accident
4	Lack of food or fluid
5	Other physiological stress

Join live classes for guided practice and doubt clearing.

DGCA-quoted — Syncope & Vasovagal Syncope

Syncope is a temporary but sudden loss of consciousness when blood flow to the brain is compromised. In young individuals, **fear, anxiety, sight of blood, etc.,** can result in a **temporary loss of consciousness.** This is referred to as **VASOVAGAL SYNCOPE.**



Frequently, syncope is associated with symptoms like:

- **Light-headedness,**
- **Muscle weakness,** and
- **Dizziness** before the actual fainting occurs.

DGCA-quoted — flight-licence implication



A faint has NO SIGNIFICANCE as far as future flying is concerned, so long as the cause is clearly understood.

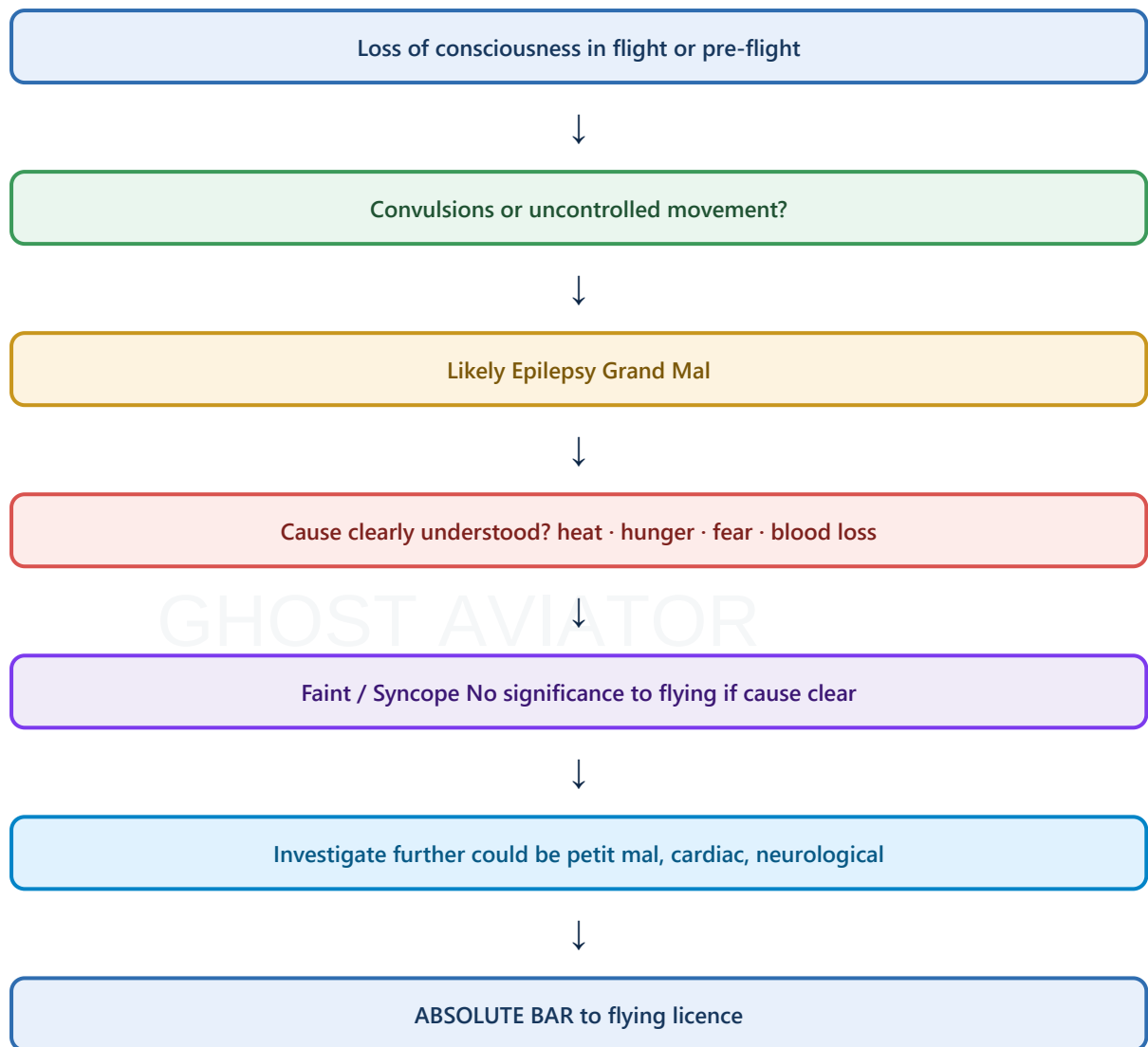


Epilepsy vs Faint — the critical comparison

This is the most frequently tested contrast in DGCA HPL papers. Memorise it:

Epilepsy vs Faint (Syncope) — side-by-side

Parameter	Epilepsy (Grand/Petit Mal)	Faint (Syncope)
Underlying cause	Disturbance of brain electrical activity	Compromised blood flow to the brain
Loss of consciousness	Often (Grand Mal) / Absent (Petit Mal)	Yes, temporary & sudden
Convulsions / uncontrolled movement	Yes (Grand Mal)	No
Predictability	Unpredictable	Cause is usually identifiable (heat, hunger, fear, blood loss)
Typical warning signs	Prodromal aura (Grand Mal)	Light-headedness, muscle weakness, dizziness
Effect on flying licence	ABSOLUTE BAR — no licence	No significance — fit to fly if cause is clear



§ R6

Self-Check, Cheat-Sheet & Mnemonics

— Part 6

Master cheat-sheet — Part 6 numbers

Every numeric / regulatory fact from Part 6

Parameter	Exact Value	Where
Normal cabin RH	40 – 60 %	\$23.1
Minor discomfort RH threshold	< 20 %	\$23.1
Native jet-cabin RH (no humidifier)	3 – 8 %	\$23.2
Cabin RH with modern humidifier (A350/787/777X)	22 %	\$23.2
Comfortable cockpit temperature	20 °C	\$24.1
Heat-stress temperature (↑ HR, ↑ BP, sweating)	30 °C	\$24.1
Skull natural resonance frequency	1 – 4 Hz	\$25.1
Eyeball natural resonance frequency	30 – 40 Hz	\$25.1
Breathing interference / neck pain frequency	1 – 4 Hz	\$25.2
Chest & abdominal pain frequency	4 – 10 Hz	\$25.2
Backache frequency	8 – 12 Hz	\$25.2
Headache · eyestrain · throat · speech difficulty · muscle tension	10 – 12 Hz	\$25.2
Vision interference frequency	30 – 40 Hz	\$25.2
Number of "obvious-incapacitation" defining attributes	6 (sudden, unpredictable, unavoidable, prolonged, complete, frequent in stress)	\$27.1

Join live classes for guided practice and doubt clearing.

Parameter	Exact Value	Where
Number of DGCA-listed causes of obvious incapacitation	5	\$27.2
Number of DGCA-listed causes of subtle incapacitation	10	\$27.3
Number of DGCA-listed causes of fainting	5	\$28.2
Effect of epilepsy on flying licence	ABSOLUTE BAR	\$28.1
Effect of a faint (cause understood) on flying licence	No significance	\$28.2

GHOST AVIATOR

GHOST AVIATOR

DGCA-style probe questions

Try these without looking back

1. State the normal range of relative humidity. At what RH does minor discomfort begin? List the four areas of dryness affected.
2. Why should diuretics like coffee and tea be avoided in flight?
3. By how much do modern aircraft humidifiers (A350, 787, future 777X) raise cabin RH?
4. List three potential problems of installing humidifiers on aircraft.
5. At what temperature is the average pilot most comfortable? At what temperature do HR, BP and sweating increase?
6. State the natural resonance frequency of (a) the skull and (b) the eyeball.
7. Reproduce the DGCA vibration-frequency effect table — five rows.
8. At what vibration frequency is vision interfered with? Why?
9. What two effects does UV radiation from sunlight have on the pilot's eyes?
-  10. State the six attributes that make in-flight incapacitation a serious safety threat.
11. What measure minimizes the risk of incapacitation? How does its frequency change with age?
12. Define obvious incapacitation. List five causes.
13. Define subtle / insidious incapacitation. State the key warning about the appearance of the affected crew member.
14. List eight causes of subtle incapacitation.
15. Why is subtle incapacitation often considered *more* dangerous than obvious incapacitation?
16. Define a fit or seizure. What does the term "epilepsy" refer to?
17. Compare Grand Mal and Petit Mal epilepsy in three respects.
18. What is the DGCA medical implication of any fit, major or minor?
19. Define a faint and list five common causes.
20. Define vasovagal syncope. What three warning symptoms typically precede the fainting?
21. What is the flying-licence implication of a faint, provided the cause is clearly understood?

Mnemonics — burn these into long-term memory

MNEMONIC — HUMIDITY RULE "40–60 normal, <20 dry." Modern humidifiers raise 3–8 % to 22 %. Avoid coffee & tea — they're diuretics.

MNEMONIC — TEMPERATURE REFERENCE "20 fine · 30 hot · >15 deviation cold." Optimal 20 °C; heat stress at 30 °C; cold loss of fine motor at >15 °C deviation from comfort.

MNEMONIC — VIBRATION BODY PARTS "S(kull) 1-4 · CA(chest/abdo) 4-10 · B(ack) 8-12 · H(ead-pain) 10-12 · V(ision) 30-40". Or: low frequency = low body, high frequency = high body.

MNEMONIC — NATURAL RESONANCE "Skull skips at 1–4. Eyes jiggle at 30–40."

MNEMONIC — OBVIOUS INCAPACITATION ATTRIBUTES "SUUPC-F" = Sudden · Unpredictable · Unavoidable · Prolonged · Complete · Frequent (in stress).

MNEMONIC — OBVIOUS INCAPACITATION CAUSES "CMICE" = Cardiac arrest · Myocardial infarction · Intracranial haemorrhage · Cerebral apoplexy (stroke) · Epilepsy.

MNEMONIC — SUBTLE > OBVIOUS "What you can't see can kill you." Subtle incapacitation is more dangerous than obvious because the other crew may not detect it.

MNEMONIC — EPILEPSY & FLYING "Any fit → no flight." Any fit (major or minor) is associated with unpredictable LoC and is an **absolute bar** to a flying licence.

MNEMONIC — FAINT CAUSES "Stand-Shock-Spill-Starve-Stress" = Stand up too quickly · Sudden Shock · Spill (loss of blood) · Starve (lack of food/fluid) · other physiological Stress.

MNEMONIC — SYNCOPE WARNING TRIO "Light-Weak-Dizzy" before fainting. *Light-headedness · Muscle weakness · Dizziness.*

MNEMONIC — FAINT VS FIT, THE LICENCE RULE "Faint = Fly. Fit = Forbidden." A faint (with a clear cause) is OK; a fit is not.

CPL · ATPL · Human Performance & Limitations Aviation Physiology & Human Factors

Part 7 of the master study set — THE EYE — anatomy · rods & cones · the fovea · binocular vision · acuity · accommodation · night vision & dark adaptation · the blind spot · visual defects · sunglasses & protection

CHAPTER

Chapter 26 (the DGCA reference textbook)

INSTRUCTOR

Ghost Aviator

EXAM

DGCA CPL / ATPL — HPL

SECTION

7 of N — Vision

Why Vision deserves its own dedicated part

The eye is — by DGCA's own description — "the most sensitive of our sensory organs" and "delivers to the brain information about the outside world at a much faster rate than any other sensory organ". In an aircraft **~80 % of the pilot's situational-awareness input is visual**: outside reference, instruments, charts, fellow traffic. Every visual fact and number in this part is HPL-exam material.



Memorise the **100 million rods / 6 million cones** ratio. Memorise **7 minutes vs 30 minutes** for cone vs rod dark adaptation. Memorise the **five visual defects** (myopia, hypermetropia, presbyopia, astigmatism, glaucoma). Memorise the **"sunglasses six"** characteristics. The DGCA examiner pulls one of these every paper.

Contents – Part 7

1. §29 The Eye — anatomy & function
2. — The Cornea, Iris, Pupil, Lens
3. — The Retina · Rods & Cones · Fovea
4. — Eye Movement & Binocular Vision
5. — Visual Acuity
6. — Accommodation & Reading Glasses
7. §30 Limitations of Acuity (Sharpness of Central Vision)
8. §31 Limitations of the Visual System
9. — Night Vision & Dark Adaptation (7 min vs 30 min)
10. — Vision under Dim & Bright Illumination
11. — Off-centre viewing — "15–20° to the side"
12. — The Blind Spot
13. — Empty Visual Field (Empty Field Myopia)
14. — Damage to the Visual System (UV at altitude)
15. — Vibrations & blurred vision
16. §32 Protection — Sunglasses
17. §33 Visual Defects
18. — Myopia · Hypermetropia · Presbyopia · Astigmatism
19. — Wearing of Corrective Spectacles
20. — Glaucoma
21. Self-Check, Cheat-Sheet & Mnemonics

§ 29

THE EYE

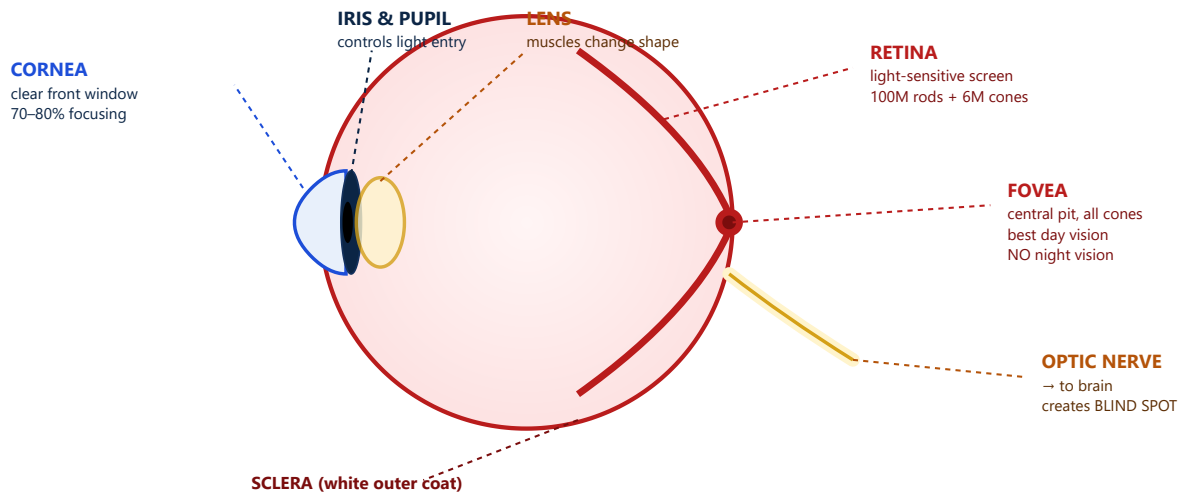
DGCA-quoted opening — the eye is the most important sensor

The eye delivers to the brain information about the outside world at a much faster rate than any other sensory organ. The eye is the organ of sight. The eye is the most sensitive of our sensory organs.



Its basic structure is similar to a **camera with an aperture (Iris), a lens (lens) and a light sensitive screen (Retina).**

Anatomy of the Human Eye



The eye works like a camera: cornea + lens focus light onto the retina; the iris/pupil controls light intake; the optic nerve carries the signal to the brain.

29.1 The Cornea, Iris & Pupil, Lens

The Cornea — DGCA-quoted

- i** Light enters the eye through the **Cornea**, a **clear window at the front of the eyeball**. The Cornea is capable of contributing **70 % to 80 %** towards the total focusing ability of the eye.

The Iris and the Pupil — DGCA-quoted

- i** The **amount of light allowed to enter the eye is controlled by the Iris**. The **Pupil**, the **hole in the center of the Iris**, adjusts to the flow of light.

The Lens — DGCA-quoted

- i** The **shape of the lens is changed by muscles**. This controls **final focusing onto the fovea**.

29.2 The Retina — Rods, Cones, and the Fovea

The Retina — DGCA-quoted



The **Retina** is a **light sensitive screen lining the inside of the eyeball**. On this screen are **light-sensitive cells**. When light falls on them, it generates a **small electrical charge which is passed to the brain by nerve fibres (neurons) which combine to form the Optic Nerve**.

Critical numbers — burn into memory

The retina has **rods in its peripheral zone** and **cones in its central zone**. The retina contains the **receptors for vision**:



- About **100 million rods**
- About **6 million cones**

100M Rods (peripheral · night vision · black & white)

6M Cones (central · day vision · colour & detail)

~17:1 Rod-to-cone ratio

The Rods

The Rods can **only detect black and white** but are **much more sensitive at lower light levels**.

Rods are responsible for our PERIPHERAL VISION.

- Located in the peripheral retina
- ~ 100 million in number
- Sensitive in dim light → night vision
- No colour information — monochrome
- Slow dark-adaptation (~ 30 min)

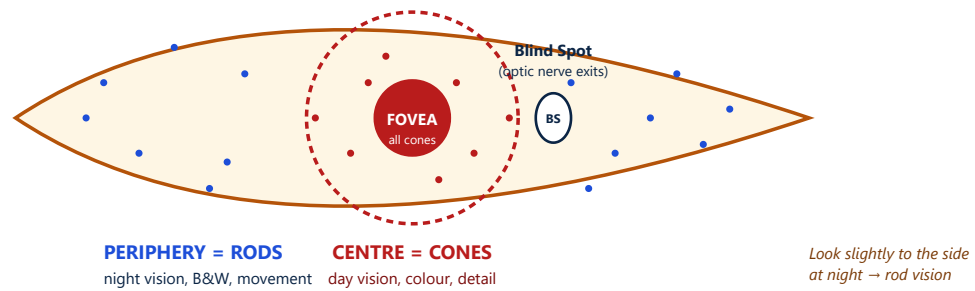
The Cones & The Fovea

The **central part of the retina is called the FOVEA**. The fovea centralis is a **small, central pit composed of closely packed cones** in the eye.

This is the area with the **best day vision and NO night vision at all**.

Any object that **needs to be examined in detail is automatically brought to focus on the fovea**. This is called **"Central Vision"**. The rest of the retina fulfils the function of **attracting our attention to movement and change**.

Where Are Rods & Cones on the Retina?



The fovea is all cones (best day vision, no night vision). Rods dominate the periphery — sensitive in dim light and to movement. At night, looking *slightly* off-axis improves your detection.

29.3 Eye Movement & Binocular Vision

Eye Movement — DGCA-quoted



To **track an object successfully, or to focus on an object**, the eyes need to move in harmony with one another. This means that the brain must **co-ordinate control of the muscles of the two eyes**. In a **fatigued person**, double vision can occur.

Binocular Vision — DGCA-quoted



Binocular Vision means seeing with **two eyes**. With binocular vision **each eye sees an object from two slightly different angles**. The brain **merges the two images into one** and is thus able to **perceive that the image has depth**.

A further advantage of binocular vision is that the **blind spot of one eye is covered by the other eye**. **Depth perception when objects are close is achieved through binocular vision**.

29.4 Visual Acuity

DGCA-quoted definition



Visual acuity is a measure of the capacity of the eye to determine SMALL DETAIL, UNDISTORTED, at a given distance.

Why acuity matters in flight



The **sharpest visual acuity** occurs when the retinal image is sharply focused on the fovea, so that the pilot needs to look **exactly in the direction of the on-coming aircraft to detect it**. It is thus **essential for pilots to have normal visual acuity**, either with the naked eye, or by wearing spectacles, in order that they may detect objects clearly at safe distance.

29.5 Accommodation & Reading Glasses

Accommodation — DGCA-quoted



As well as being able to see objects clearly at a distance, **pilots also need good near vision in order to read instruments and maps**. Being able to **focus on close objects** is a function of the eye's ability to accommodate.

Reading Glasses — DGCA-quoted



Pilots and drivers who have reached middle-age normally wear bi-focal spectacles to allow them to see clearly at a distance and to read their instruments and maps, while wearing the same spectacles.

CORNEA — % OF TOTAL
FOCUSING

70 – 80 %

RODS TOTAL

~ 100 million

CONES TOTAL

~ 6 million

BEST DAY VISION AREA

Fovea (all cones)

FOVEA NIGHT VISION

NONE

PILOT MIDDLE-AGE GLASSES

Bi-focal

§ 30

Limitations of Acuity — Sharpness of Central Vision

DGCA-quoted



The sharpness of central vision **drops as light falls on retina at increasing angles from the fovea**. The following factors affect the sharpness of central vision:

Twelve factors that affect the sharpness of central vision (DGCA verbatim)

#	Factor	Pilot Note
1	Angular distance from the fovea	Acuity is maximum on the fovea, drops sharply off-axis.
2	Physical imperfections within the visual system	Refractive errors, cataract, retinal disease.
3	Age	Presbyopia, lens stiffening, declining contrast sensitivity.
4	Hypoxia	Retina has very high O ₂ demand — first system to suffer (§10).
5	Smoking	CO + nicotine reduce retinal perfusion (§13).
6	Alcohol	Histotoxic mechanism degrades cells including retinal photoreceptors (§14).
7	Amount of light available	Photopic / mesopic / scotopic — acuity scales with luminance.
8	Size and contours of an object	Large object with clear contour = easier; small or amorphous = harder.
9	Distance of the object from the viewer	Resolvable detail falls off with distance.
10	Contrast of an object with its surrounding	Low contrast = hard to see (e.g. white aircraft in cloud).
11	Relative motion of a moving object	A constant-bearing target on collision course is <i>hardest</i> to detect.
12	Drugs or medication	Many OTC and prescription meds cause blurred vision or accommodation problems.

§ 31

LIMITATIONS OF THE VISUAL

Join live classes for guided practice and doubt clearing.

31.1 Night Vision & Dark Adaptation — the critical 7 vs 30 minutes

DGCA-quoted definition

Adaptation is the adjustment of the eyes to high or low levels of illumination.



The time required for:

- Complete adaptation for HIGH levels of illumination is **10 seconds**, and
- For full DARK adaptation, **30 minutes**.

Why pilots care — DGCA-quoted



When passing from bright ambient surroundings into the dark, visual capacity is severely reduced until the eyes have adapted to the dark. It is especially important for pilots to allow sufficient time for dark adaptation to take place before flying at night.

Cones vs Rods — the two-stage dark adaptation

Dark adaptation takes time:



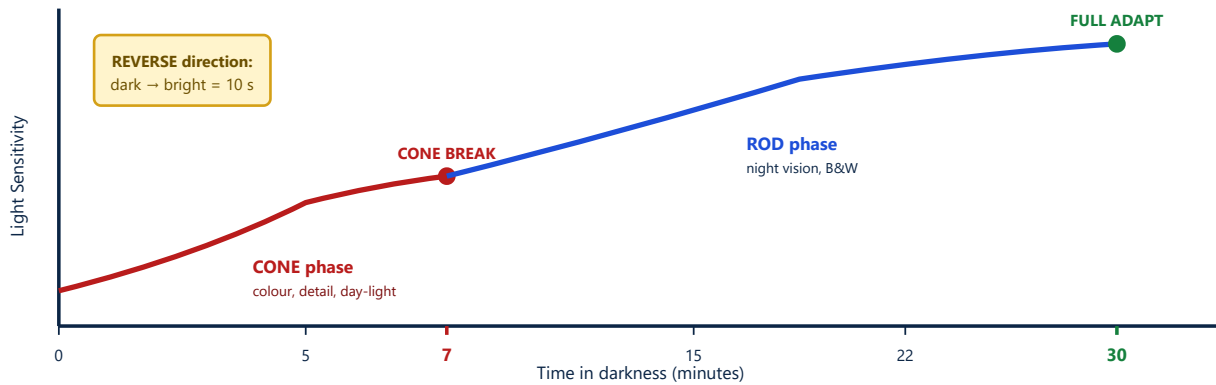
- About **7 minutes** for the CONES,
- And **30 minutes** for the RODS.

10s Bright-light adaptation (dark → bright)

7_{min} Cones — partial dark adaptation

30_{min} Rods — FULL dark adaptation

Dark Adaptation Curve — Cones First (7 min), Then Rods (30 min)



Cones complete their dark adaptation in ~7 minutes, but full sensitivity awaits the slower rods at ~30 minutes. The reverse process (adapting to bright light from dark) takes only ~10 seconds.

31.2 Vision Under Dim & Bright Illumination

DGCA-quoted

Under conditions of **dim illumination, small print and colors on aeronautical charts and aircraft instruments become unreadable unless adequate cockpit lighting is available.** Moreover, another aircraft must be much closer to be seen **unless its navigation lights are on.**



In darkness, vision becomes more sensitive to light, a process called **dark adaptation**. Although exposure to **total darkness for at least 30 minutes is required for complete dark adaptation**, a pilot can achieve a **moderate degree of dark adaptation within 20 minutes under dim red cockpit lighting.**

Why red light — and when NOT to use it (DGCA-quoted)



Since red light severely distorts colors, especially on aeronautical charts, and can cause serious difficulty in focusing the eyes on objects inside the aircraft, its use is advisable **ONLY** where optimum outside night vision capability is necessary.

Even so, white cockpit lighting must be available when needed for map and instrument reading, especially under IFR conditions.

DGCA-quoted — dark-adaptation killers

Dark adaptation is impaired by:



- Exposure to cabin pressure altitudes above 5,000 feet,
- Carbon monoxide inhaled in smoking and from exhaust fumes,
- Deficiency of Vitamin A in the diet, and
- By prolonged exposure to bright sunlight.

DGCA-quoted — the "close one eye" preservation trick



Since any degree of dark adaptation is lost within a few seconds of viewing a bright light, a pilot should close one eye when using a light to preserve some degree of night vision.

31.3 Off-Centre Viewing — "Look 15–20° to the Side"



DGCA-quoted — the night-vision technique

Look to the side (15 – 20 deg) of the object.

Why off-centre viewing works at night



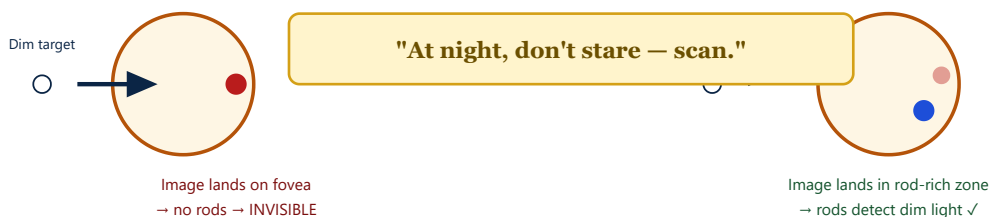
The fovea has **no rods** — and therefore **no night vision**. When you stare *directly* at a dim object at night, its image falls on the fovea, where there are zero rods → you cannot see it. By looking **15–20° to the side**, you place the image on the **rod-rich peripheral retina** where night vision is sharpest.

Counterintuitive but vital: at night, the way to see something is NOT to look at it. This is taught in night-VFR training as "**off-centre / scan viewing**".

Off-Centre Viewing at Night — Why It Works

A. Stare directly = INVISIBLE

B. Look 15–20° off = VISIBLE



Direct stare puts the target on the fovea (no rods, no night vision). Looking 15–20° to the side places it on the rod-rich peripheral retina — and the dim object becomes visible.

31.4 The Blind Spot

DGCA-quoted



The **blind spot** is point on the retina where the optic nerve enters the eyeball. Here the retina has **no covering of light-detecting cells**.

Why this matters for see-and-avoid



If the eye remains **looking straight ahead**, it is possible for a **closing aircraft to remain in the blind spot until a very short time before impact**. To lessen the danger of collision, pilots are taught to **carry out a SYSTEMATIC LOOK OUT at all times**.

With both eyes open, the blind spot of one eye is covered by the other eye. But be aware of obstructions to your visual field such as passengers or canopy structures.

31.5 Empty Visual Field (Empty Field Myopia)

DGCA-quoted



In the **absence of anything to focus on** (that is when your visual field is empty), the **natural focus point of the eye is, on average, at a distance of between**

1 and 2 meters in front of the eye.

Pilots should **minimize the risks associated with empty visual field by periodically and deliberately focusing on objects, both close and at a distance**.

The danger — "empty field myopia"



At high altitude with a clear blue sky and no clouds, your eye relaxes to its **resting focal length of 1-2 m** — well inside the cockpit. A distant aircraft becomes **blurry and easy to miss**. Mitigation: deliberately re-focus the eyes by looking at the wingtip, then at the horizon, then at a distant ground feature. This pumps the ciliary muscles and breaks empty-field myopia.

31.6 Damage to the Visual System — UV at Altitude

DGCA-quoted



Very high light occurs at altitude. At altitude, light contains **more of the high energy blue and ultraviolet wavelengths than is experienced at sea level.** Over a long period, such light can cause **cumulative damage to the retina and lens of the eye.** However, **most harmful wavelengths are filtered out by the cockpit windows.**

31.7 Vibrations & Blurred Vision

DGCA-quoted



Vibrations can cause blurred vision. This is due to TUNED RESONANCE oscillations of the eyeballs.

*(Recall §25 — the eyeball's natural resonance is **30–40 Hz**. Aircraft vibration that hits that band → vision-blur. This is one of the most direct cross-links between Part 6 and Part 7.)*

§ 32

Protection of the Visual System — Sunglasses

DGCA-quoted — flash-blindness protection in thunderstorms

When flying through a thunderstorm with lightning you can protect yourself from FLASH BLINDNESS by:



- **Turning up the intensity of cockpit lights,**
- **Looking inside the cockpit,**
- **Wearing sunglasses, and**
- **Using face blinds or face curtains when installed.**

DGCA-quoted — what good sunglasses must do

The requirement of good sunglasses is to:



- Absorb at least **85 %** of visible light to eliminate glare without decreasing visual acuity,
- Absorb UV and IR radiation,
- Absorb all colors equally.

Make sure you avoid using cheap sunglasses. Light sensitive lenses (Photo chromatic) are also generally forbidden for use in flight.

DGCA-quoted — sunglasses characteristics (the "six" list)

Sunglasses should have the following characteristics:



1. Be impact resistant.
2. Have thin frames (minimum visual obstruction).
3. Be coated with poly carbonate for strength.
4. Be of good optical quality.
5. Have a luminescence transmittance of **10 - 15 %**.
6. Possess appropriate filtration characteristics.

SUNGLASS LIGHT ABSORPTION
≥ 85 %

SUNGLASS LUMINESCENCE
TRANSMITTANCE
10 - 15 %

PHOTOCHROMATIC LENSES
Forbidden in flight

FRAME COATING FOR
STRENGTH
Polycarbonate

§ 33

VISUAL DEFECTS



DGCA-quoted opening

The most common visual defects are caused by the distorted shape of the eyeball.

33.1 The Four Refractive Defects — Myopia, Hypermetropia,

Presbyopia, Astigmatism

MYOPIA (Short-sightedness)

Myopia is more commonly known as **short-sightedness**. In a myopia eye, the **eyeball is LONGER than normal** causing the **image to fall in FRONT of the retina**.

Correction: A **CONCAVE lens** will correct Myopia by **bending the light from distant objects OUTWARDS before it hits the cornea**.

Normal pilot distance vision: "may be very approximately assessed as the ability to **read a car number plate at 40 meters**".

HYPERMETROPIA (Long-sightedness)

Hypermetropia is also known as **long-sightedness**, because **only objects at a distance can be seen clearly**.

Correction: A **CONVEX lens** will overcome Hypermetropia by **bending the light rays from near objects INWARDS before they meet the cornea**.

(Eyeball is shorter than normal — image would form behind the retina. Convex lens converges the rays earlier.)

PRESBYOPIA

Presbyopia is the **inability of the lens to change its shape to accommodate adequately**, to focus as an image from a near object onto the retina.

This condition normally arises in people **between the ages of 40 and 50**. It is a **form of long-sightedness** and is **corrected using a CONVEX lens**.

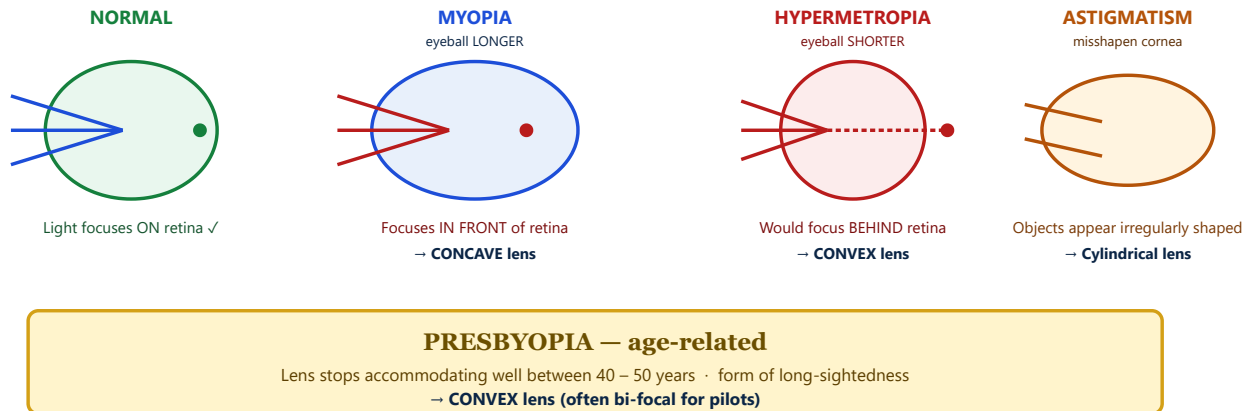
(This is why pilots at middle age often need bi-focals — see §29.5.)

ASTIGMATISM

Astigmatism is caused by a **misshapen or oblong cornea**. For a person with astigmatism **objects will appear irregularly shaped**.

(Corrected with a cylindrical lens that compensates for the corneal irregularity.)

Refractive Defects — Where Light Focuses



Myopia (eyeball too long → image in front of retina → concave lens), Hypermetropia (eyeball too short → image behind retina → convex lens), Astigmatism (misshapen cornea → cylindrical lens), Presbyopia (age-related loss of accommodation, 40–50 yrs → convex lens).

Refractive Defects — Memory Table

Defect	Common Name	Mechanism	Correction
Myopia	Short-sightedness	Eyeball longer → image in front of retina	Concave lens
Hypermetropia	Long-sightedness	Eyeball shorter → image behind retina (only distance clear)	Convex lens
Presbyopia	Age-related (40–50 yrs)	Lens can't change shape — accommodation fails	Convex lens (often bi-focal)
Astigmatism	—	Misshapen / oblong cornea — objects irregular	Cylindrical lens

33.2 Wearing of Corrective Spectacles by Pilots

DGCA-quoted rule



Pilots who wear corrective spectacles or contact lenses, for whatever reason, must carry a SPARE PAIR at all times when they are exercising the privileges of their license.

33.3 Glaucoma

Glaucoma — DGCA-quoted (the most aviation-medically important visual defect)

Glaucoma is characterized by:



- **Progressive narrowing of the visual field,**
- **Insidious onset and concealed progression,**
- **An increase in intra-ocular pressure.**

Glaucoma can lead to total blindness and undetected reduction of the visual field. It reduces visual acuity in its final stage.

Why glaucoma is screened at every pilot medical



The word "**insidious**" + "**concealed**" + "**undetected reduction of visual field**" is what makes glaucoma so dangerous to aviation. A pilot may be losing peripheral vision over months or years and not realise it — until a critical traffic conflict or runway-incursion-detection failure exposes it.

Intra-ocular pressure (IOP) measurement (tonometry) is part of every routine Class-1 / Class-2 DGCA medical precisely to catch glaucoma early.

§ R7

Self-Check, Cheat-Sheet & Mnemonics

Join live classes for guided practice and doubt clearing.

— Part 7

Master cheat-sheet — Part 7 numbers

Every numeric / regulatory fact from Part 7

Parameter	Exact Value	Where
Cornea — % of total focusing ability	70 - 80 %	\$29.1
Number of rods in retina	~ 100 million	\$29.2
Number of cones in retina	~ 6 million	\$29.2
Rod location	Peripheral retina	\$29.2
Cone location	Central retina (Fovea)	\$29.2
Best day vision area	Fovea (all cones)	\$29.2
Fovea night-vision capability	NONE	\$29.2
Bi-focal age (DGCA implied)	Middle-age	\$29.5
Number of factors that affect central-vision sharpness	12	\$30
Adaptation: dark → bright	10 seconds	\$31.1
Adaptation: bright → dark (FULL)	30 minutes	\$31.1
Cone dark-adaptation	7 minutes	\$31.1
Rod dark-adaptation (full)	30 minutes	\$31.1
Moderate dark adaptation under dim red light	20 minutes	\$31.2
Dark adaptation impaired above cabin altitude	5,000 ft	\$31.2

Join live classes for guided practice and doubt clearing.

Parameter	Exact Value	Where
Off-centre night-viewing angle	15 – 20 degrees	§31.3
Eye natural resting focal length (empty field)	1 – 2 m in front of eye	§31.5
Eyeball natural resonance (vision blur)	30 – 40 Hz	§31.7
Sunglasses — visible light absorption	≥ 85 %	§32
Sunglasses — luminescence transmittance	10 – 15 %	§32
Photochromatic lenses in flight	Forbidden	§32
Sunglasses characteristics — count	6	§32
Normal distance vision benchmark	Read car plate at 40 m	§33.1 (Myopia)
Presbyopia onset age	40 – 50 years	§33.1
Spare-spectacles rule	Mandatory carry	§33.2
Number of visual defects covered	5 (Myopia, Hypermetropia, Presbyopia, Astigmatism, Glaucoma)	§33

GHOST AVIATOR

DGCA-style probe questions

Try these without looking back

1. State the percentage contribution of the cornea to the total focusing ability of the eye.
2. How many rods and how many cones does the retina contain? Where is each type located?
3. Define the fovea. Why does it provide the best day vision but no night vision?
4. Define binocular vision and state two advantages of having two eyes.
5. Define visual acuity. Why is normal acuity (with or without spectacles) essential for pilots?
6. What is accommodation? Why do middle-aged pilots wear bi-focals?
7. List six factors that affect the sharpness of central vision.
8. How long does it take for (a) full bright adaptation, (b) cone dark adaptation, (c) rod dark adaptation?
9. Why is red cockpit lighting useful for preserving dark adaptation? What is its main drawback?
10. List four factors that impair dark adaptation.
11. At what angle off-axis should a pilot look to use rod (peripheral) vision at night?
-  12. Explain what the "blind spot" is and how binocular vision compensates for it.
13. Define empty visual field. At what distance does the eye naturally focus in an empty field? How should the pilot mitigate this?
14. State four protective measures against flash blindness in a thunderstorm.
15. State three required properties of good aviation sunglasses (light absorption, UV/IR, equal-colour absorption). What is the luminescence transmittance range?
16. List all six DGCA-listed characteristics of pilot sunglasses.
17. Are photochromatic lenses allowed in flight?
18. Define myopia and hypermetropia. Name the corrective lens type for each.
19. Define presbyopia. At what age does it typically arise? What lens corrects it?
20. Define astigmatism. What causes it?
21. State the DGCA rule on a pilot who wears corrective lenses regarding the carriage of spectacles.
22. Define glaucoma. State three of its characteristics. Why is it of particular aero-medical concern?

Mnemonics — burn these into long-term memory

MNEMONIC — RODS VS CONES

"Rods are Plenty & Peripheral — see at Night." 100 million Rods, peripheral retina, monochrome, dim-light.

"Cones are Clustered & Central — see in Colour." 6 million Cones, central retina (fovea), colour, daylight.

MNEMONIC — CORNEA CONTRIBUTION

"70 to 80 cornea-focus." The cornea — not the lens — does most of the eye's focusing.

MNEMONIC — DARK ADAPTATION TIMES

"10 seconds bright, 7 minutes cones, 30 minutes rods." The three iconic numbers — the DGCA examiner mixes them in MCQs every year.

MNEMONIC — DARK-ADAPTATION KILLERS

"ACCB" = **A**ltitude above 5,000 ft cabin · **C**arbon monoxide (smoking/exhaust) · **C**arrots-low (Vitamin A deficiency) · **B**right sun exposure.

MNEMONIC — OFF-CENTRE VIEWING

"Look 15 – 20 to the side at night." Avoid the cone-only fovea; use the rod-rich periphery.

MNEMONIC — EMPTY FIELD FOCUS

"Empty sky, eye at one to two metres." Pump the eyes by re-focusing on wingtip/horizon/ground feature periodically.

MNEMONIC — SUNGLASSES 85/10-15

"Eighty-five absorb, ten to fifteen pass." ≥85 % light absorption, 10–15 % luminescence transmittance.

MNEMONIC — SUNGLASSES CHARACTERISTICS

"I-T-P-O-L-F" = **I**mpact resistant · **T**hin frames · **P**olycarbonate coating · **O**ptical quality good · **L**uminescence 10–15 % · **F**iltration appropriate.

MNEMONIC — REFRACTIVE DEFECTS VS LENS

"Myopia → Mini (concave) · Hyperopia → Hyper (convex) · Presbyopia → Plus (convex) · Astigmatism → Axis (cylindrical)."

Join live classes for guided practice and doubt clearing.

MNEMONIC — PRESBYOPIA AGE "40-to-50, lens stops being fifty-fifty." Accommodation fails between 40 and 50 years of age.

MNEMONIC — GLAUCOMA TRIO "Narrow-field · Sneaky-onset · High-pressure." Progressive narrowing of visual field · insidious/concealed onset · raised intra-ocular pressure.

MNEMONIC — PILOT'S "SPARE-PAIR" RULE "If you fly with glasses, fly with spares."
Mandatory — DGCA-quoted.

CPL · ATPL · Human Performance & Limitations Aviation Physiology & Human Factors

Part 8 of the master study set — Colour Vision & Colour Blindness · Vision & Speed (Reaction Times) · The Ear (Outer-Middle-Inner) · Eustachian Tube & Otic Barotrauma · Audible Range & Hearing Loss · The Balance Mechanism · Proprioception · Vestibular Apparatus · Orientation Factors · Conflicts & Illusions (intro)

CHAPTER

Chapter 26 (the DGCA reference textbook)

INSTRUCTOR

Ghost Aviator

EXAM

DGCA CPL / ATPL — HPL

SECTION

8 of N — Hearing, Balance & Orientation

Where Part 8 sits in the picture

Part 7 closed with the eye and the five visual defects. Part 8 finishes the vision topic with **colour vision & colour blindness** and the link between vision and aircraft closing speeds, then crosses into the next major sensory organ — **THE EAR** — covering hearing physiology, the Eustachian tube and ear-clearing on descent, audible range, noise-induced hearing loss, and finally the **BALANCE MECHANISM**: proprioception, the vestibular apparatus (otoliths + semi-circular canals), the three orientation factors, and the bridge into spatial disorientation & illusions (covered in detail in Part 9).



Contents – Part 8

- | | |
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| 1. §34 Colour Vision | 12. §41 Protection of Hearing |
| 2. §35 Colour Blindness | 13. §42 The Ear and Balance · Orientation |
| 3. §36 Vision & Speed — Reaction Times | 14. §43 THE BALANCE MECHANISM |
| 4. §37 THE EAR — two functions, three sections | 15. — Proprioception |
| 5. §38 The Middle and Inner Ear · The Eustachian Tube | 16. — Vestibular Apparatus (Otoliths + Semi-Circular Canals) |
| 6. — Otic Barotrauma & "step descent" | 17. — The Three Orientation Factors |
| 7. §39 Audible Range of the Human Ear | 18. — How angular acceleration is sensed |
| 8. §40 Noise & Hearing Loss | 19. §44 Conflicts Between Ears & Eyes (intro) |
| 9. — Conductive Deafness | 20. §45 ILLUSIONS — Atmospheric Perspective · Gestalt Laws |
| 10. — Noise-Induced Hearing Loss (>80 dB / >90 dB) | 21. Self-Check, Cheat-Sheet & Mnemonics |
| 11. — Presbycusis | |

Colour Vision

DGCA-quoted



Good color vision is essential for pilots because of the use of color associated with the items listed below.

Why pilots need good colour vision — DGCA-listed items

#	Item	Operational use of colour
1	Navigation light of aircraft	Red (left wingtip) · Green (right) · White (tail) — defines aircraft direction at night.
2	Runways and airfields	White runway edge lights · red runway end · green threshold · PAPI (white/red) glide-path.
3	Ground obstructions	Red obstruction lights on towers · obstacle markings.
4	Cockpit displays and instruments	Red = warning · amber = caution · green = normal · cyan = sky · brown = ground (PFD).
5	Maps and charts	VFR/IFR charts use colour-coded airspace, terrain, MSA values.
6	Emergency flares	Distress flares — red = distress · white = signalling.
7	Light signals	ATC light-signal codes (steady green = clear to land · red flashing = airport unsafe, etc.)

Colour Blindness

DGCA-quoted definition



Color blindness or, more accurately, color-defective vision, is caused by a defect in the structure of the color-sensitive cones in the retina.

Why this connects directly to §29.2



Recall from Part 7 that **cones are the colour-sensitive photoreceptors** packed into the fovea — about **6 million** of them. If their *structure* is defective (most commonly a missing or weak red, green, or blue pigment), the brain cannot distinguish between certain colours. This is most commonly genetic (sex-linked recessive — far more common in males) and is non-treatable.

DGCA-medical implication



Colour-defective vision (red-green most commonly) is screened at every DGCA Class-1 / Class-2 medical using the **Ishihara colour plates**. Significant deficiency can disqualify a candidate, or restrict the licence to "day-VFR only" because of the night colour-signal interpretation problem (nav lights, PAPI, ATC light signals all rely on red/green discrimination).

GHOST AVIATOR

§ 36

Vision & Speed — Reaction Times

DGCA-quoted



Reaction time depends on the closing relative speed of two aircraft. If one of the aircraft were to be a fast jet, the closing speed would be much higher.

Why this matters operationally — see-and-avoid limitations

At a closing speed of **1,000 kt** (two fighters head-on, each at 500 kt), aircraft cover roughly **0.5 nm per second**. The human eye + brain typically needs:



- ~ **0.1 s** to detect a moving target
- ~ **1 s** to recognise it as another aircraft
- ~ **1 s** to decide on an evasive action
- ~ **4 s** for the controls + airframe to respond

That's **≈ 6 seconds** from "first photon hitting the retina" to "aircraft actually moving out of the way" — at 1,000 kt closing, the other aircraft has already covered **~ 3 nm**. The pilot must therefore detect the conflict at a range that allows for these reaction-time bites; this is why **systematic scan**, **traffic alerts**, and **TCAS** exist.

THE EAR — Two Functions, Three Sections

DGCA-quoted — the two functions of the ear

The ear performs two quite separate functions:



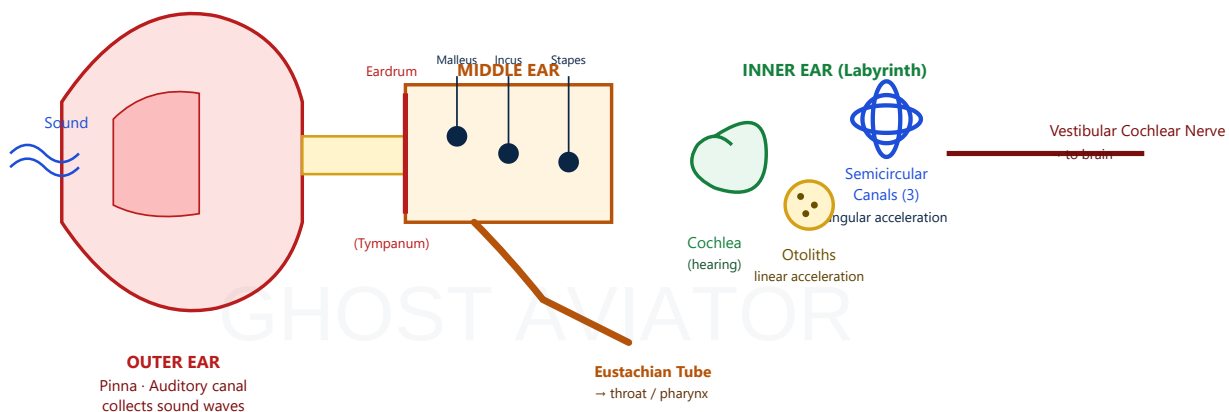
- To receive vibrations or sound waves in the air which it transmits to the brain.
- To act as a balance organ and acceleration director.

Why this distinction is critical



Most students think of the ear as the "hearing organ" only. The second function — **balance** — is arguably more important for pilots, because **spatial disorientation kills pilots, hearing loss usually doesn't**. The vestibular apparatus inside the inner ear (covered in §42–43) is what tells you which way is up — when it lies to you, you crash.

Anatomy of the Human Ear — Outer, Middle & Inner



The ear has three sections — Outer (pinna + canal), Middle (eardrum + ossicles + Eustachian tube), Inner (cochlea for hearing; otoliths + semi-circular canals for balance).

The Middle and Inner Ear • The Eustachian Tube



DGCA-quoted

The **Tympanum** and the **Ossicles** transmit sound waves to the inner ear.

The **Tympanum** is the eardrum. The **Ossicles** are the three smallest bones in the body — **Malleus**, **Incus**, **Stapes** (Hammer, Anvil, Stirrup). They form a tiny amplifying lever system that converts air pressure waves at the eardrum into mechanical motion at the oval window of the cochlea.

38.1 The Eustachian Tube — pressure equalisation



DGCA-quoted

The **Eustachian tube** allows pressure in the middle ear to equalize across the ear drum with outside or ambient pressure when climbing or descending.



DGCA-quoted — the no-fly rule

No one should fly if their Eustachian tube is blocked, and they cannot "clear" their ears.

38.2 Effects of Altitude Change — Clearing the Ears



DGCA-quoted — descent is the dangerous phase

It is during **DESCENT** when difficulty in clearing the ears is most likely to be experienced.



Why descent — the one-way-valve effect

On **climb**, ambient pressure falls; the higher-pressure middle-ear air *pushes outward* through the Eustachian tube — this happens easily and automatically. On **descent**, ambient pressure rises; the now-relatively-lower-pressure middle-ear air must *draw in* through the Eustachian tube against gravity and tissue swelling. The tube tends to act like a one-way flap valve. If congested (cold, flu, sinusitis), it fails to open and the eardrum is pushed inward by external pressure — **Otis Barotrauma**.

38.3 Otis Barotrauma

DGCA-quoted definition



Otis Barotrauma — Stretching of the ear drum caused by the expansion and contraction of gases trapped in the inner ear by a blocked Eustachian tube.

DGCA-quoted clearing techniques + "step descent"

If you experience problems with pressure equalization during descent:

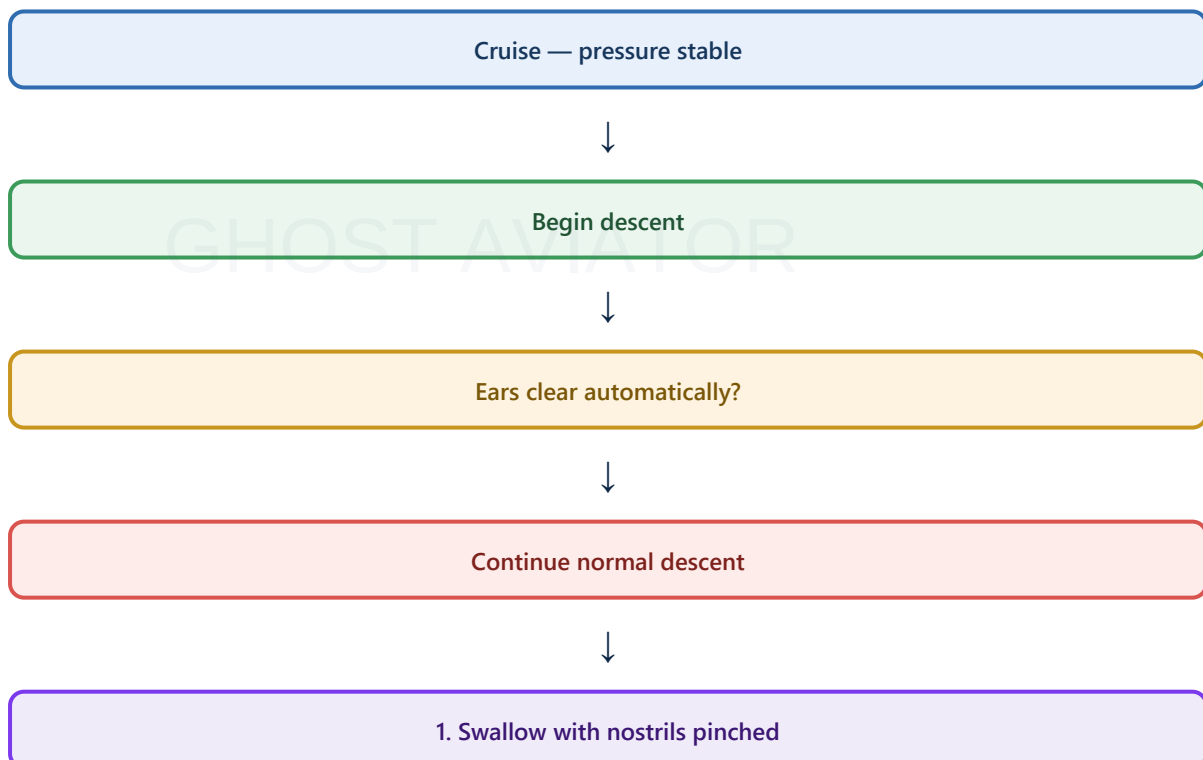
1. **Swallow deliberately** with the nostrils pinched closed,
2. **Yawn**,
3. **or BLOW DOWN THE NOSE**, again with the nostrils pinched closed. *(This is the Valsalva manoeuvre.)*

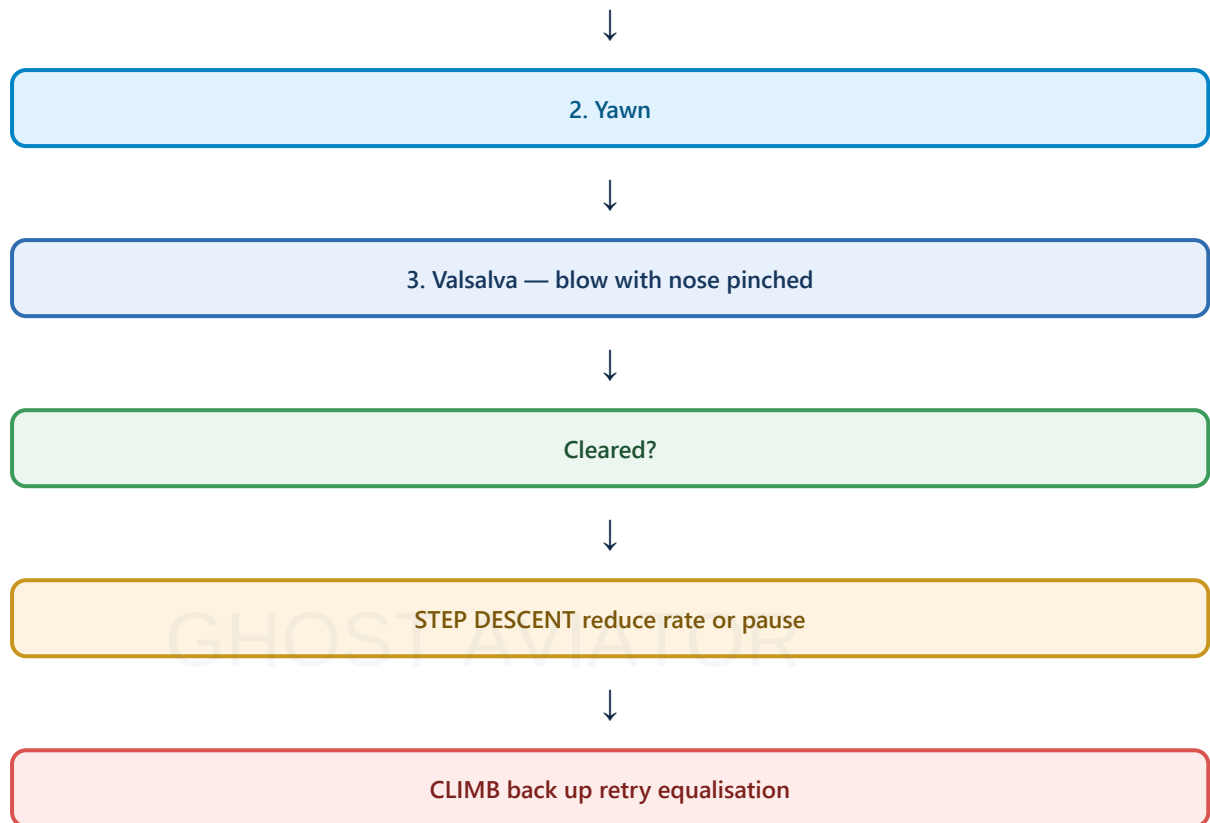


If the problem is not resolved, **the rate of descent should be decreased or stopped at intervals to allow more time for pressure to equalize. This is also known as STEP DESCENT.**

Pilot may resort to even CLIMB if pressure persists. Re-climbing reduces external pressure and helps un-block the tube.

Remember, never fly if your Eustachian tube becomes swollen or blocked and you cannot clear your ears.





§ 39

Audible Range of the Human Ear

DGCA-quoted — sound has three main qualities



- **Pitch** — which depends on the **frequency** of the vibration.
- **Loudness or Intensity** — which depends on the **amplitude** of the vibrations.
- **Quality** — which can be either **harmonious or just plain noisy**.

DGCA-quoted — frequency range



The range of **pitch or frequency of sounds that a fit young person can hear lies between 16 and 20,000 Hertz**, or cycles per second. **Detectable sound range also depends on loudness.**

16_{Hz} Lower limit of audible frequency

20,000_{Hz} Upper limit (fit young person)

3^{qualities} Pitch · Loudness · Quality

DGCA-quoted — four causes of hearing impairment

Hearing impairment can arise because of:



1. Exposure to loud noise.
2. Physical damage to the hearing mechanism.
3. Advanced age.
4. A buildup of wax.

40.1 Conductive Deafness



DGCA-quoted

Conductive Deafness — is caused by damage to the ossicles or the ear drum.

40.2 Noise-Induced Hearing Loss — the 80 / 90 dB thresholds

DGCA-quoted — exact dB thresholds

Noise Induced Hearing Loss:



- > 80 dB — task performance may be impaired.
- > 90 dB — measurable impairment of task performance.

DGCA-quoted — the counterintuitive "arousal" effect

However, it has been shown that in some situations performance of VIGILANCE tasks can actually be BETTER in high noise levels than in low noise levels. This is because noise increases AROUSAL and can move the individual into the optimum performance area.



Any prolonged exposure to noise in excess of 90 dB can end up in noise-induced hearing loss. This can damage the very sensitive membrane in the cochlea.

40.3 Presbycusis — Hearing loss with age

DGCA-quoted



Presbycusis — is the name given to the deterioration of hearing with advanced age. **HIGH TONES** are cut off **FIRST**.

AUDIBLE RANGE YOUNG

16 – 20,000 Hz

PERFORMANCE IMPAIRED
ABOVE

80 dB

MEASURABLE IMPAIRMENT
ABOVE

90 dB

CONDUCTIVE DEAFNESS —
SITE

Ossicles / eardrum

AGE-RELATED HEARING LOSS
TERM

Presbycusis

PRESBYCUSIS — FIRST TO GO

High tones

NOISE DAMAGE SITE

Cochlear membrane

"OPTIMUM" ZONE OF NOISE-
AROUSAL

~ 70 – 80 dB

(implied)

§ 41

Protection of Hearing

DGCA-quoted



Noise induced hearing loss can be avoided or reduced to a minimum by wearing suitable **EAR PROTECTORS**.

Always protect your ears if you know you are going to be exposed to excessive noise. In the cockpit, use the best quality **HEADSET** you can afford in order to reduce background noise.

Practical cockpit application



- **Active Noise Reduction (ANR) headsets** — provide both passive (foam seal) and active (anti-phase electronic cancellation) noise attenuation. Reduce cockpit noise by 15–25 dB.
- **Maintenance crews on ramp** — must use over-the-ear muffs near running engines (105–130 dB at engine intakes).
- **Earplugs alone** — useful for passengers; usually inadequate for sustained cockpit duty.
- **Cumulative exposure** — even short bursts of 130+ dB (gunfire, jet blast) can cause permanent damage. Each pilot's hearing is a non-renewable career asset.

§ 42

The Ear and Balance · Orientation

DGCA-quoted definition



"Orientation" refers to a human being's ability to maintain equilibrium and to interpret the body's position in space. The ear also provides us with our sense of balance.

DGCA-quoted — VISION is primary



The primary and most reliable sense of spatial orientation is EYESIGHT.

The balance sensors situated in the ear provide us with a **SECONDARY** system.

Why this hierarchy matters



This is the single most important fact in spatial-disorientation training. The eyes are primary; the ear's balance organ is secondary. When the two disagree — as happens in IMC (Instrument Meteorological Conditions) where the eyes lose external reference — **the pilot must trust the instruments (which calibrate to true vertical), not the inner ear (which lies)**. This is the foundational principle of IFR (Instrument Flight Rules).

43.1 Proprioception

DGCA-quoted definition



Proprioception: is the **awareness of the body in space**. It is the use of **joint position sense and joint motion sense** to respond to stresses placed upon the body by alteration of posture and movement.

43.2 The Vestibular Apparatus — Otoliths & Semi-Circular Canals

DGCA-quoted — memorise the components & functions



The **Vestibular apparatus (Otoliths + Semi-circular canals)** helps maintain spatial orientation.

- The **Otoliths** detect **LINEAR ACCELERATION**.
- The **Semi-Circular Canals** detect **ANGULAR ACCELERATION**.

OTOLITHS — linear acceleration

The otoliths are tiny **calcium-carbonate crystals embedded in a gelatinous membrane** sitting on top of hair cells in the utricle and saccule.

- **Sense linear acceleration:** forward/back (takeoff, braking), up/down (turbulence, climb/dive)
- Also sense **gravity at rest** (which way is "down")
- Can be tricked by sustained acceleration → "**somatogravic illusion**" (Part 9)

SEMI-CIRCULAR CANALS — angular acceleration

Three fluid-filled loops at right angles to each other (one per axis: roll, pitch, yaw). Each ends in an **ampulla** containing a cupula with hair cells.

- **Sense angular acceleration:** turning, pitching, rolling
- Only respond to **change** in rotation, not steady rotation
- Can be tricked by sustained turns → "**the leans**" / spiral dive illusion (Part 9)

43.3 The Three Orientation Factors — DGCA's "Big Three"

DGCA-quoted — the three factors

Human beings maintain spatial orientation using a combination of three factors:



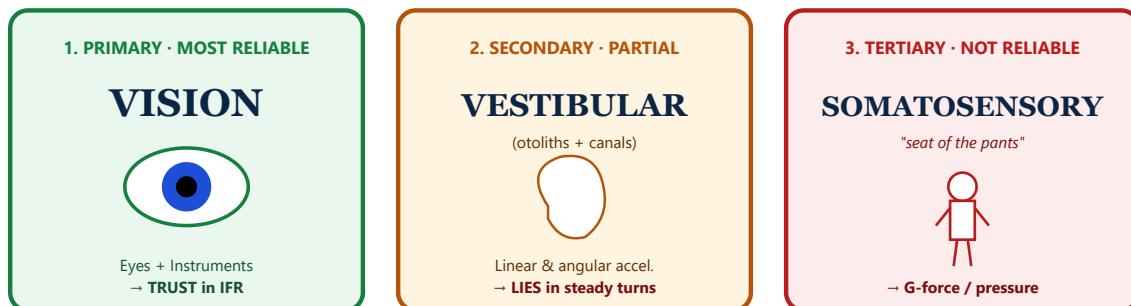
1. The sense of vision.
2. The Vestibular Apparatus.
3. The Somatosensory system ("seat of the pants" feeling) / G-Force.

DGCA-quoted — reliability ranking (memorise verbatim)



- The most reliable sense is the **SENSE OF VISION**.
- Our vestibular apparatus can detect accelerations but cannot determine what position we are in if no acceleration is present.
- The somatosensory system is **NOT RELIABLE AT ALL**.
- Neither is the ear's balancing mechanism sufficiently reliable for a pilot to maintain spatial orientation using this sense alone.

The Three Orientation Factors — Ranked by Reliability



"Vision is primary; the vestibular apparatus is partial; the somatosensory system is not reliable at all."

*Vision is the primary and most reliable source of orientation. The vestibular apparatus is a partial secondary system.
The "seat of the pants" somatosensory feeling is not reliable at all.*

43.4 How Angular Acceleration is Sensed — DGCA-quoted

The fluid-flow mechanism



- Both the Otoliths Organs and the Semi-Circular Canals send signals to our brain by means of impulses arising from the body being subjected to accelerations.
- Fluid flow occurs when the body is subject to angular acceleration.
- The flow takes place in the **OPPOSITE direction to the acceleration**, moving **sensory hairs** which send signals to the brain that the body is in motion.

The crucial failure mode — DGCA-quoted



There is **NO FLUID FLOW** when the body is at rest or if linear or turning movement is taking place at a **STEADY SPEED**. In these situations, the vestibular apparatus alone **CANNOT DETECT MOTION**.

Only the eyes and instruments tell a pilot that he is in a steady turn.

Why this is the foundation of "the leans"



In a steady-rate turn, the canal fluid catches up with the canal walls and stops flowing. The sensory hairs return to centre — the brain thinks "**no turn is taking place**". If the pilot then rolls out, the fluid *now* flows (in the opposite sense to the roll-out) → the brain interprets this as *a turn in the opposite direction*. The pilot, feeling that "wing-low" sensation, tends to re-roll back into the original turn = **graveyard spiral**. The cure: trust the attitude indicator, not the inner ear. (Detailed Part 9 — illusions.)

§ 44

Conflicts Between Ears & Eyes — Illusions & Disorientation / Vertigo

DGCA-quoted



Various complex motions and forces and certain visual scenes encountered in flight can create **ILLUSIONS** of motion and position.

Spatial disorientation from these illusions can be prevented **ONLY** by visual reference to **RELIABLE, FIXED POINTS** on the ground or to **FLIGHT INSTRUMENTS**.

DGCA-quoted definition

In aviation any mismatch between what we sense and what we expect is an illusion.



Because of the lack of stable visual references and the erroneous mental models that may be produced, the **pilot is at a disadvantage**.

DGCA-quoted — universality and danger



- **Illusions may occur during all stages of the flight, and to pilots of every experience and skill level.**
- The pilot, therefore, should be **aware of the possibility of misinterpreting the information received**.
- **Visual illusions are particularly dangerous in aviation, as we normally consider our visual input to be the most reliable of our senses.**

45.1 Atmospheric Perspective

DGCA-quoted



The pilot who has flown mostly in relatively polluted air may use "atmospheric perspective" as a cue to range. If he then flies in a very clear atmosphere he may believe distant objects, because of their clarity, to be much closer than they actually are.

Practical example — flying over the desert / over the ocean / above an inversion



A pilot accustomed to hazy/polluted urban airspace develops a mental ruler: "*if the runway looks sharp, it must be close*". On a crystal-clear day above the desert or over an ocean inversion, that same runway looks "close" at 5+ miles — the pilot starts the descent too early, undershoots, or arrives high & fast at the threshold. The illusion runs the other way too: in a polluted layer, the runway looks "farther" → late descent, dive at the runway.

45.2 Laws of Perceptual Organisation — Gestalt Theory

DGCA-quoted

The "**Laws of perceptual organization of Gestalt Theory**" deal with factors such as:



- **Proximity,**
- **Continuity,**
- **Similarity,**
- **Symmetry,**
- **Simplicity,** and
- **Closure.**

Gestalt laws formulate basic principles governing **how objects are organised and perceived**.

Why Gestalt matters in cockpit display design



The reason a glass cockpit groups *related* data (engine N1/EGT/Fuel-flow on one column; flight-attitude/heading/altitude as a single PFD) is **Gestalt proximity & similarity**. The pilot's brain naturally fuses these into one "engine block" or one "primary flight" gestalt — reducing scan workload. Misdesigned displays violate Gestalt principles and slow the pilot's interpretation under stress.

§ R8

Self-Check, Cheat-Sheet & Mnemonics

— Part 8

Master cheat-sheet — Part 8 numbers & facts

Every numeric / regulatory / definitional fact from Part 8

Parameter	Exact Value / Fact	Where
Number of DGCA-listed pilot uses of colour	7	\$34
Cause of colour blindness	Defect in colour-sensitive cones	\$35
Reaction time depends on	Closing relative speed	\$36
Two functions of the ear	Hearing + Balance/accel.	\$37
Three sections of ear	Outer · Middle · Inner	\$37
Three ossicles (smallest bones)	Malleus · Incus · Stapes	\$38
Difficulty clearing ears — when	During DESCENT	\$38.2
Otis Barotrauma — cause	Blocked Eustachian tube	\$38.3
Three ear-clearing techniques	Swallow · Yawn · Valsalva	\$38.3
If clearing fails — descent technique	STEP DESCENT	\$38.3
Three qualities of sound	Pitch · Loudness · Quality	\$39
Pitch depends on	Frequency	\$39
Loudness depends on	Amplitude	\$39
Audible frequency range (young)	16 – 20,000 Hz	\$39
Number of causes of hearing impairment	4	\$40
Conductive deafness — site	Ossicles or eardrum	\$40.1
Task performance impaired above	80 dB	\$40.2

Join live classes for guided practice and doubt clearing.

Parameter	Exact Value / Fact	Where
Measurable impairment above	90 dB	\$40.2
Noise-induced damage site	Cochlear membrane	\$40.2
Age-related hearing loss term	Presbycusis	\$40.3
Presbycusis — first to disappear	High tones	\$40.3
Primary sense of spatial orientation	EYESIGHT	\$42
Ear balance system rank	Secondary	\$42
Proprioception	Awareness of body in space	\$43.1
Vestibular apparatus components	Otoliths + Semi-circular canals	\$43.2
Otoliths detect	LINEAR acceleration	\$43.2
Semi-circular canals detect	ANGULAR acceleration	\$43.2
Three orientation factors	Vision · Vestibular · Somatosensory	\$43.3
Most reliable orientation sense	VISION	\$43.3
Least reliable orientation sense	Somatosensory ("seat of pants")	\$43.3
Fluid flow direction vs acceleration	OPPOSITE	\$43.4
Vestibular fails in steady-speed motion	No fluid flow → no signal	\$43.4
Steady-turn detection requires	Eyes + instruments only	\$43.4
Definition of an illusion	Mismatch sense vs expect	\$45
Gestalt principles — count	6	\$45.2

DGCA-style probe questions

Try these without looking back

1. List seven DGCA-quoted reasons pilots need good colour vision.
2. What causes colour blindness, anatomically?
3. State the two distinct functions of the ear.
4. Name the three ossicles. What do they do?
5. What does the Eustachian tube do? When can a pilot NOT fly because of it?
6. During which phase of flight is ear-clearing most difficult? Why?
7. Define Otis Barotrauma. State the three deliberate clearing techniques.
8. What is meant by "step descent"? When else may the pilot resort to a climb?
9. Name the three qualities of sound and what each depends on.
10. State the audible frequency range of a fit young person.
11. List the four DGCA-listed causes of hearing impairment.
12. Define conductive deafness. Define presbycusis. Which tones disappear first in presbycusis?
-  13. State the dB threshold above which task performance may be impaired, and the dB threshold for measurable impairment.
14. Explain the counter-intuitive "high-noise may improve vigilance" effect.
15. Define orientation. Which sense is primary, and which is secondary?
16. Define proprioception.
17. What two components make up the vestibular apparatus? What does each detect?
18. Rank the three orientation factors by reliability.
19. What is the somatosensory system? How reliable is it?
20. What happens (in fluid-flow terms) when the body is in a steady-speed turn? What can detect motion in this condition?
21. Define an illusion in aviation context.
22. How can spatial disorientation from illusions be prevented?
23. Explain the "atmospheric perspective" illusion. What direction of error does flying in clear air cause?
24. List the six Gestalt principles of perceptual organisation.

Mnemonics — burn these into long-term memory

MNEMONIC — PILOT USES OF COLOUR (7)

"**NRGC MEL**" = **N**av lights · **R**unways & airfields · **G**round obstructions · **C**ockpit displays · **M**aps · **E**mergency flares · **L**ight signals.

MNEMONIC — OSSICLES HEAD-TO-TAIL

"**MIS**" = **M**alleus → **I**ncus → **S**tapes (Hammer → Anvil → Stirrup) — same order from eardrum to oval window.

MNEMONIC — EAR CLEARING (3 STEPS)

"**Swallow · Yawn · Valsalva**" in that order. If still blocked: **step-descend or even re-climb**.

MNEMONIC — AUDIBLE RANGE & SOUND QUALITIES

"**16 to 20K — Pitch, Loud, Quality.**" Audible 16–20,000 Hz. Three qualities of sound: pitch (frequency), loudness (amplitude), quality (harmonious/noisy).

MNEMONIC — NOISE THRESHOLDS

"**80 maybe, 90 measurable.**" >80 dB = task *may* be impaired. >90 dB = *measurable* impairment.

MNEMONIC — PRESBYCUSIS

"**Old ears lose the highs first.**" Age-related hearing loss = presbycusis; high tones cut off first.

MNEMONIC — VESTIBULAR COMPONENTS

"**Otoliths Line · Canals Curve.**" Otoliths detect linear acceleration. Semi-circular canals detect angular (curve) acceleration.

MNEMONIC — THREE ORIENTATION FACTORS

"**V·V·S**" = **V**ision (best) · **V**estibular (partial) · **S**omatosensory (worst).

MNEMONIC — WHY INSTRUMENTS MATTER IN STEADY TURN

"**No flow = no clue.**" In a steady-speed turn, vestibular fluid stops flowing → vestibular thinks "no turn". **Only the eyes & instruments will save you.**

MNEMONIC — DEFINITION OF ILLUSION

"Sense $\neq$ Expect = Illusion."

MNEMONIC — GESTALT SIX

"PCSSSC" = Proximity · Continuity · Similarity · Symmetry · Simplicity · Closure.

CPL · ATPL · Human Performance & Limitations Aviation Physiology & Human Factors

Part 9 of the master study set — SPATIAL DISORIENTATION & ILLUSIONS — taxiing · take-off (somatogravic) · cruise (auto-genesis) · approach & landing (black-hole · runway-width & slope · texture flow · ground proximity) · linear accel illusions (Head-Up · Head-Down · Elevator) · False Horizon · vection illusions · Geometric Perspective · Stroboscopic/Flicker · Disorientation summary · Motion sickness · Acceleration & G-forces (intro)

CHAPTER

Chapter 26 (the DGCA reference textbook)

INSTRUCTOR

Ghost Aviator

EXAM

DGCA CPL / ATPL — HPL

GHOST AVIATOR

Why Part 9 is the most operationally lethal block of this chapter

Spatial disorientation kills pilots. In every aviation jurisdiction's accident database, a significant share of fatal accidents — particularly at night, in IMC, or in mountainous terrain — trace back to **a pilot acting on what their senses said while ignoring what the instruments said**. This part covers every illusion the DGCA syllabus names — by far the longest illusion catalogue in any aviation textbook — plus motion sickness and the start of G-force physiology.



The unifying principle, repeated almost as a mantra, is: **"If you suspect disorientation, concentrate on and believe in aircraft instruments in IMC. If in VMC, look out at the horizon."** Every other line in Part 9 is detail underneath that one sentence.

Contents – Part 9

1. §46 Illusions When Taxiing — Relative Movement
2. §47 Illusions on Take-off — Somatogravic Illusion
3. §48 Outside References — six false-impression triggers
4. §49 Illusions in the Cruise — Auto-genesis · Vertical Separation
5. §50 Approach & Landing — three stages
6. — Initial Judgment of Glide Slope
7. — Width & Slope of Runways
8. — Black Hole Effect
9. — Visual illusions on approach — ground lighting · shallow vs steep approach triggers
10. — Maintenance of Glide Slope · Texture & Texture Flow
11. — Ground Proximity Judgments
12. §51 Protective Measures Against Illusions
13. §52 Disorientation / Vertigo — the master rule
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19. §58 Geometric Perspective Illusion
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23. Self-Check, Cheat-Sheet & Mnemonics

§ 46

Illusions When Taxiing — Relative Movement

DGCA-quoted general warning



We must use extreme caution to ensure that we do not construct our mental model according to our wishes or desires.

DGCA-quoted — taxi illusion



When taxiing into a headwind the blowing snow will give the illusion that the aircraft is taxiing faster than it actually is.

Cockpit cross-check



The fix is simple — verify against the **ground-speed display on the FMS/GPS**, the **brake-pedal feel**, or by looking at **fixed reference markers** (runway centreline, taxiway edge lights). Never rely on the relative motion of mobile elements (snow, rain droplets, dust) as a speed reference.

§ 47

Illusions on Take-off — Somatogravic Illusion



DGCA-quoted

Acceleration gives the pilot an impression of the nose of the aircraft pitching UP.

Why — the otolith physics

The **otoliths** (Part 8 §43.2) sense linear acceleration. During take-off, strong forward acceleration deflects the otolith hair cells in the same direction *that gravity would deflect them if the head were tilted back*. The brain cannot tell these apart — so it interprets forward acceleration as **nose-up pitch**.



The reflex response of the disoriented pilot is to **push the nose down** — into the ground. This is the classic **Somatogravic Illusion** killer on night/IMC departures, and is the principle behind a string of fatal accidents on dark-night take-offs over water.

Outside References — Six False-Impression Triggers

DGCA-quoted — verbatim list

Outside references may give a false impression within the cockpit:

1. Immediately after take-off.
2. Over water.
3. In hilly terrain.
4. Gently sloping terrain.
5. A bank of sloping cloud.
6. The ground sloping down on the approach.



Why these six are dangerous — common thread



Each of these scenarios **removes or distorts a clear, unambiguous horizon**. The pilot's brain — which is wired to use the horizon as its vertical reference — substitutes **whatever long, straight, dark-light boundary it can find** (a coastline, a hill ridge, a cloud bank top). If that boundary is sloped, the pilot subconsciously aligns the wings with *it* instead of with the true horizon — and ends up in a banked or pitched attitude without realising it.

Illusions in the Cruise — Auto-genesis & Vertical Separation

49.1 Auto-genesis (the autokinetic effect)

DGCA-quoted

Auto genesis. Staring at an isolated and stationary light when other visual references are inadequate or absent, may cause auto-kinetic movements of the eyes.



In the dark, a static light will appear to move about when stared at for many seconds. The disoriented pilot will lose control of the aircraft in attempting to align it with the light.

Practical example & defence



A single distant aircraft light, a star, a ground beacon, or the planet Venus on a clear dark night — fixate on it for 6–12 seconds and it appears to drift, dance, or even rotate. The pilot may attempt to follow this "moving" target with control inputs. The defence: **do not stare**. Scan your visual field continuously, with brief stops on any reference. If a single light source *seems* to move, glance away briefly and verify against the attitude indicator and other lights.

49.2 Vertical Separation

DGCA-quoted



A common problem in flight is the evaluation of the relative altitude of approaching aircraft and the assessment of a potential collision risk.

Why visual altitude assessment of another aircraft is unreliable



At distance, an aircraft is reduced to a point of light or a tiny silhouette. There is no reliable monocular cue to its altitude relative to your own. A constant-bearing approaching target (no relative motion across your windscreen) is the classic collision-course signature — and the most difficult to detect visually. Modern transport aircraft therefore rely on **TCAS** (Traffic Collision Avoidance System) and ATC altitude verification, not on the pilot's eye, for vertical separation.

§ 50

Approach and Landing — Three Stages

DGCA-quoted

In the final stages of a flight the pilot has to cope with the most critical visual tasks, and these may be divided into 3 stages:



1. Initial judgment of glide slope
2. Maintenance of the glide slope
3. Ground proximity judgments.

50.1 Initial Judgment of Appropriate Glide Slope

DGCA-quoted — the "Visual Angle"



Visual Angle — To judge the approach path, the pilot is attempting to establish an angle. **This angle is the "Visual Angle" and is measured at the pilot's eye DOWN FROM THE HORIZON to the visual aiming point on the runway.**

50.2 Width & Slope of Runways

DGCA-quoted — Width of Runways illusion



The width of the runway may also cause incorrect height judgments on the final approach.

A pilot used to a **standard width runway** may, when approaching an **unfamiliar NARROW runway**, judge he is too high and therefore round out too low on approach.

The inverse — wide runway illusion



By the same physics, an unusually **WIDE** runway looks **closer / lower than it is** → pilot perceives "too low", rounds out too high, lands long and hard.

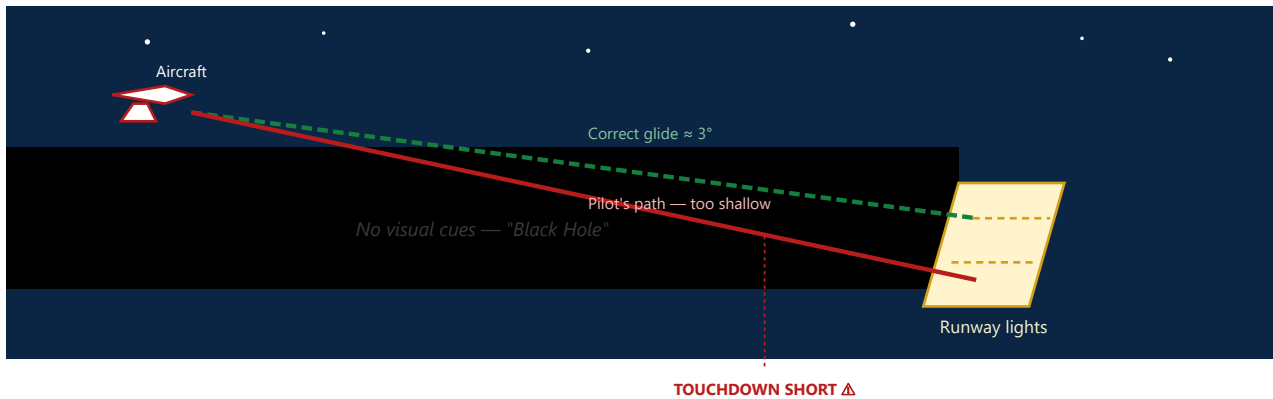
50.3 The Black Hole Effect

DGCA-quoted — verbatim



The Black Hole Effect — The absence of visual cues (such as **night-time approaches over desert or unlit water**) leads to an illusion that the **aircraft is TOO HIGH**, as a result the approach path may be flown at **too shallow an angle**, the aircraft may **touch down SHORT of the runway**. This specific illusion is often called the **"black-hole illusion"**, due to the apparent visual "black hole" between the aircraft and the runway.

The Black Hole Effect — Why Pilots Land Short



With no intervening lights between aircraft and runway (night over water/desert), the pilot's brain misjudges the visual angle, flies too shallow, and lands short of the threshold.

50.4 Visual Illusions on Approach

DGCA-quoted — Ground Lighting Illusions

Lights along a straight path, such as a road, and even lights on moving trains can be mistaken for runway and approach lights.



Bright runway and approach lighting systems, especially where few lights illuminate the surrounding terrain, may create the illusion of **less distance to the runway**. The pilot who does not recognize this illusion will **fly a HIGHER approach**.

Conversely, the pilot **overflying terrain which has few lights to provide height cues** may make a **LOWER-than-normal approach**.

(a) Shallow Approaches — DGCA verbatim

Triggers that **create the illusion of being HIGH** → **resulting in SHALLOWER approach**:

- **Up-slope runway or terrain**
- **Narrower than usual runway**
- **Feature-less terrain**
- **Rain on the wind screen**
- **Haze**

Result: pilot thinks "too high" → reduces descent rate → flies shallow → may land short or hit obstacles.

(b) Steep Approaches — DGCA verbatim

Triggers that **create the illusion of being LOW** → **resulting in STEEPER (HIGH) approach**:

- **Down-sloping runway or terrain**
- **Wider than usual runway**
- **Bright runway / approach lights**

Result: pilot thinks "too low" → increases descent rate → flies steep → may land long or run off the end.

Runway / approach features → perceived position → pilot's wrong reaction

Visual Feature	Pilot perceives	Reaction	Outcome
Narrower than usual runway	"Too high"	Reduces rate of descent	Shallow approach · land short / low round-out
Wider than usual runway	"Too low"	Increases rate of descent	Steep approach · land long / high round-out
Up-sloping runway/terrain	"Too high"	Shallow approach	Low / land short
Down-sloping runway/terrain	"Too low"	Steep approach	High / land long
Featureless terrain	"Too high"	Shallow	Low / land short (black-hole family)
Rain on windshield / haze	"Too high"	Shallow	Low / land short
Bright runway / approach lights	"Too low" (looks close)	Steep	High / land long
Few terrain lights below	"Higher than reality"	Shallow	Lower than normal approach
Black hole (no cues between)	"Too high"	Shallow	Land short

50.5 Maintenance of the Glide Slope

DGCA-quoted — Aiming Pilot & Aircraft Attitude Pitch Angle



Once established on the glide path, it is relatively easy to visually maintain the glide path by keeping the aiming point at a **FIXED POSITION** on the windscreen.

DGCA-quoted — Inadvertent Speed Loss trap



On the approach, with an **inadvertent speed loss** and a **gradual loss of altitude**, the **runway could remain in the same position on the windscreen**, giving the impression of a safe approach, until touch down occurs some distance **BEFORE** the threshold.

Texture and Texture Flow — DGCA-quoted

As long as visual texture flows **AWAY FROM** the aiming point and the visual angle between this point and the horizon remains constant, the approach will progress normally.



("Texture flow" = the pattern of ground objects (runway markings, taxiway lights, surrounding terrain detail) appearing to flow outward and past you. If the flow point sits **ON** the aiming spot, you are tracking towards it. If the flow seems to converge ahead of the aiming spot, you are undershooting; behind it, overshooting.)

50.6 Ground Proximity Judgments

DGCA-quoted — height-assessment cues

The pilot will use a number of cues in his height assessment on the final stage of the approach, among which will be:



- That the apparent speed of objects on the ground will **INCREASE** as the height reduces.
- That the **SIZE** of objects, such as runway lights etc., will **INCREASE** with decreasing distance.
- That the apparent **WIDTH** of the runway will **INCREASE**.
- That the **TEXTURE** of the ground will **CHANGE**.

STAGE 1 OF APPROACH VISUAL TASK

Initial glide-slope judgment

STAGE 2 OF APPROACH VISUAL TASK

Maintenance of glide slope

STAGE 3 OF APPROACH VISUAL TASK

Ground-proximity judgments

VISUAL ANGLE REFERENCE

Horizon → aiming point

AIMING-POINT POSITION RULE

Fixed on windscreen

NUMBER OF GROUND-PROXIMITY CUES

4 (speed · size · width · texture)

§ 51

PROTECTIVE MEASURES AGAINST ILLUSIONS

DGCA-quoted — verbatim

Organized formal training is the best protective measure against illusions. It is recommended that this should be used to educate pilots to recognize:

- 
- 1. The illusions are natural phenomena.**
 - 2. Know the different types of illusions and their effects.**
 - 3. That the supplementation of other visual cues with information from other sources is the most effective counter to the effects of illusions.**
 - 4. The need for comprehensive flight briefing should the occurrence of illusions be known to exist or are anticipated at particular geographic locations.**
 - 5. Special care must be taken during accelerations and particularly during instrument flying.**
 - 6. Head movements, fatigue, night and conditions of reduced visibility are all factors that can promote visual illusions.**

§ 52

Disorientation / Vertigo — The Master

Rule

DGCA-quoted — the most important sentence in this entire part



If you suspect disorientation, concentrate on and BELIEVE in aircraft Instruments in IMC. If in VMC, look out at the HORIZON.

Why this is the cardinal rule

Every other illusion-management technique in §51 is preparation. **This sentence is the action.** The moment you suspect you are disoriented, you have a binary choice tree:



- **In IMC (cloud, night, no horizon)** → *scan and obey the instruments*. The artificial horizon (attitude indicator), altimeter, VSI, ASI, heading indicator, and turn coordinator are unaffected by illusions and tell you what's true. Override the seat-of-the-pants feeling.
- **In VMC (clear day with horizon)** → *look out at the real horizon* and re-anchor your spatial reference to it. Don't fixate on instruments.

There is no third option. There is no "wait it out". The disorientation will not self-resolve while you ignore both the instruments and the horizon.

§ 53

Air / Motion Sickness

DGCA-quoted



Air/Motion Sickness — this mismatch between vestibular and visual sensory input is the PRIMARY CAUSE of spatial disorientation, and indeed of motion sickness.

Vibrations within the frequency band of 1/10 to 2 Hertz are a factor contributing to airsickness, because they upset the vestibular apparatus.

Symptoms of Motion Sickness — DGCA verbatim



- Nausea and fear
- Hyperventilation
- Vomiting
- Pallor
- Cold sweating
- Headache
- Depression

0.1–2_{Hz} Vibration band that upsets the vestibular system

7^{symptoms} DGCA-listed symptoms of motion sickness

V vs V Vestibular vs Visual mismatch — root cause

§ 54

Linear-Acceleration Illusions — Head-Up & Head-Down

(b)

Head-Up Illusion

Definition (DGCA-quoted): *This illusion involves a sudden forward LINEAR ACCELERATION during level flight where the pilot perceives that the nose of the aircraft is PITCHING UP.*

Perceived: nose pitching UP. **Triggers (DGCA-quoted):** Night takeoff from a well-lit airport into a dark sky, OR application of full power during a missed instrument approach. **Reflex (wrong) response:** the pilot would be to **push the control forward to pitch the nose of the aircraft DOWN** → flies into the ground.

(c)

Head-Down Illusion

Definition (DGCA-quoted): *The head-down illusion involves a sudden linear DECELERATION (e.g., application of air brakes, lowering flaps, decreasing engine power) during level flight.*

Perceived: nose pitching DOWN. **Reflex (wrong) response:** the pilot's response would be to **RAISE the nose of the aircraft, which may lead to a STALL if executed during a low-speed final approach.**

Underlying physics — same as Somatogravic illusion (§47)

Both illusions are **somatogravic** — otolith deflection by linear acceleration interpreted as a tilt of the head/body relative to gravity. The general rule:



- **Acceleration FORWARD** → otoliths sense as **HEAD-BACK / NOSE-UP** → reflex push forward (Head-Up illusion / take-off somatogravic).
- **Deceleration (acceleration BACKWARD)** → otoliths sense as **HEAD-FORWARD / NOSE-DOWN** → reflex pull back (Head-Down illusion).

Both kill by reflex-induced loss of aircraft attitude. **Defence in both: scan the attitude indicator.**

§ 55

Elevator Illusion

DGCA-quoted



An abrupt **UPWARD** vertical acceleration, usually by an **UPDRAFT**, can create the illusion of being in a **CLIMB**. The disoriented pilot will push the aircraft into a **NOSE LOW** attitude.

An abrupt **DOWNWARD** vertical acceleration, usually by a **DOWNDRAFT**, has the opposite effect, with the disoriented pilot pulling the aircraft into a **NOSE UP** attitude.

When this kills



This is the family of illusions that traps pilots in **convective turbulence (CB cells, mountain wave, microbursts)**. The vertical kicks of strong updraft/downdraft trick the vestibular sense into perceiving a sustained climb/dive. The pilot's "correction" — pushing or pulling — superimposes on whatever the vertical motion already is, producing wild pitch excursions and potentially loss of control or wing stall.

Defence: in turbulence, fly the attitude (pitch ~3-5° up, wings level), not the airspeed. Let the altimeter swing. Avoid sudden corrective inputs based on seat-of-pants sensation.

False Horizon

DGCA-quoted



Sloping cloud formations, an obscured horizon, a dark scene spread with ground lights and stars, and certain geometric patterns of ground light can create illusions of **NOT BEING ALIGNED CORRECTLY** with the actual horizon. The disoriented pilot will place the aircraft in a **DANGEROUS ATTITUDE**.

The four DGCA-listed False Horizon triggers



1. Sloping cloud formations
2. An obscured horizon
3. A dark scene spread with ground lights and stars
4. Certain geometric patterns of ground light

The "ground lights = stars" trap



On a clear dark night over remote terrain, scattered ground lights below merge visually with stars above — the boundary between them (the true horizon) disappears. The pilot's brain then picks the brightest cluster of ground lights and treats it as "ground" or "below" — but if those lights are on a hillside above the aircraft's altitude, the brain has been told the wrong direction is down. This is one of the most lethal night-VFR illusions.

Vection Illusions

"Vection" is the sense of **self-motion induced by viewing motion of the surroundings**. Three forms are recognised in the DGCA syllabus:

57.1

Circular Vection

DGCA-quoted: *Is the sensation of self-rotation induced by viewing a surround rotating about the observer's vertical axis.*

(Example: standing still in a slowly spinning room — you feel as if you are rotating instead.)

57.2

Join live classes for guided practice and doubt clearing.

Linear Vection

DGCA-quoted: During linear vection, the observer feels like they have moved forwards or backwards and the stimulus has stayed stationary.

(Example: seated in a stationary train when the adjacent train moves — you feel your train is moving.)

57.3

Roll Vection

DGCA-quoted: During roll vection, the observer feels like they have rotated around the line of sight and the disk has stayed stationary.

(Example: the brain interprets a rolling visual surround as the body rolling, even when the body is stationary.)

§ 58

Geometric Perspective Illusion

DGCA-quoted — short and broad definition



Geometric Perspective Illusion — any misinterpretation by the visual system of a figure made of **STRAIGHT** or **CURVED** lines.

Why it matters in aviation



Runway markings, approach light bars, painted aprons, taxiway centrelines, even cloud-bank edges — all are made of straight or curved lines. The brain extracts depth, distance, and orientation from these lines using assumptions (parallel lines converge, near things look bigger, etc.). Anything that breaks those assumptions (e.g. a runway painted with a converging perspective deception, or an upslope that looks like a level runway from far away) creates a geometric-perspective illusion.

§ 59

The Stroboscopic Effect (Flicker

Vertigo)

DGCA-quoted definition



An additional type of vertigo is known as **Flicker vertigo**. Light, flickering at certain frequencies, from **four to twenty times per second (4 – 20 Hz)**, can produce **unpleasant and dangerous reactions** in some people.

DGCA-quoted reactions

These reactions may include:



- **Nausea**
- **Dizziness**
- **Unconsciousness**
- **Even reactions similar to an EPILEPTIC FIT**

DGCA-quoted causes in flight



- In a **single-engine propeller aeroplane heading into the sun**, the propeller may cut the sun to give this flashing effect, **particularly during landing when the engine is throttled back**.
- These undesirable effects may be avoided by **not staring directly through the prop for more than a moment**, and by making **frequent but small changes in RPM**.
- The **flickering light traversing helicopter blades** has been known to cause this difficulty.
- The **bounce back from rotating beacons on aircraft which have penetrated clouds** — if the beacon is bothersome, **shut it off during these periods**.

DGCA-quoted — recommended preventative actions

If a member of the crew or a passenger shows symptoms of the Stroboscopic Effect, the recommended preventative actions are:



1. **Turn the aircraft away from the sun.**
2. **Move the person affected to the shade.**
3. **Make the individual close eyes.**

Disorientation Summary — REMEMBER

DGCA-quoted — six summary statements (verbatim)

1. Without visual aid, a pilot often interprets CENTRIFUGAL FORCE as a sensation of RISING or FALLING.
2. Abrupt head movement during a prolonged constant-rate turn in IMC or simulated instrument conditions can cause pilot disorientation. (*This is "Coriolis illusion" / somatogyral cross-coupling.*)
3. A sloping cloud formation, an obscured horizon, and a dark scene spread with ground lights and stars can create an illusion known as FALSE HORIZONS.
4. An abrupt change from climb to straight and level flight can create the illusion of TUMBLING BACKWARDS.
5. A rapid acceleration during takeoff can create the illusion of being in a NOSE-UP attitude.
6. Symptoms of hypoxia may be difficult to recognize BEFORE the pilot's reactions are affected.



Acceleration and "G" Forces — Introduction

DGCA-quoted — definition of 1 G

Flying can expose the human body to conditions for which it is not naturally suited. On the ground, the body is subject to normal gravitational acceleration: "1G". This is **32 ft/sec² or 9.81 m/sec²**. The reaction of the earth's surface to this acceleration gives us the sensation we call "weight".



A pilot will experience 1 G in straight and level flight.

61.1 Load Factor at Bank Angles

DGCA-quoted — load-factor numbers (memorise)



- At **60° of bank** a pilot is subject to an acceleration of **2 G** acting vertically through his seat. His weight will also **increase by a factor of 2**. This is called the **LOAD FACTOR**.
- In a **70° level turn**, the load factor increases to **3**.

1 G Straight & level flight ($32 \text{ ft/s}^2 \cdot 9.81 \text{ m/s}^2$)

2 G 60° level bank turn

3 G 70° level bank turn

DGCA-quoted — aerobatic certification



A typical **light aircraft cleared for aerobatics** would be **stressed to withstand positive load factors of up to 6**.

61.2 Counter-measures against adverse G-effects

DGCA-quoted



The **adverse effects of increased "G"** can be delayed or relieved by:

- Tensing the thigh and stomach**, and
- Easing off the backward pressure on the control column**.

Physiological background



Under high positive G, blood pools in the lower body — **cerebral blood pressure drops**. Early symptoms are **greyout** (loss of peripheral vision), then **blackout** (loss of central vision), then **G-LOC** (G-induced Loss of Consciousness). Tensing the lower body's muscles (the "AGSM" — Anti-G Straining Manoeuvre) raises arterial pressure and forces blood back up to the brain. Easing off the control column reduces the G being demanded.

(More detail in continuation of the chapter.)

GHOST AVIATOR

GHOST AVIATOR

— Part 9

Master cheat-sheet — Part 9 numbers & rules

Every numeric / regulatory / definitional fact from Part 9

Parameter	Exact Value / Fact	Where
Outside-reference false-impression triggers — count	6	\$48
Approach-and-landing critical visual stages	3	\$50
Visual Angle definition	Horizon → aiming point on runway	\$50.1
Narrow-runway illusion	"Too high" → round out too low	\$50.2
Black-hole illusion result	Touch down SHORT	\$50.3
Black-hole illusion typical scenario	Night over desert / unlit water	\$50.3
Shallow-approach triggers count	5	\$50.4
Steep-approach triggers count	3	\$50.4
Ground-proximity height cues	4 (speed · size · width · texture)	\$50.6
Protective measures against illusions — count	6	\$51
Master rule — in IMC	Believe the instruments	\$52
Master rule — in VMC	Look at the horizon	\$52
Motion-sickness vibration band	0.1 – 2 Hz	\$53
Motion-sickness symptoms count	7	\$53
Primary cause of motion sickness	Vestibular-visual mismatch	\$53
Head-Up illusion = response	Push forward → dive	\$54 (b)

Join live classes for guided practice and doubt clearing.

Parameter	Exact Value / Fact	Where
Head-Down illusion = response	Pull back → stall	\$54 (c)
Updraft → perceived as	Climb (pilot pushes nose down)	\$55
Downdraft → perceived as	Descent (pilot pulls nose up)	\$55
False-horizon triggers count	4	\$56
Vection types	3 (Circular · Linear · Roll)	\$57
Flicker-vertigo frequency band	4 – 20 Hz	\$59
Flicker-vertigo reactions count	4	\$59
Flicker-vertigo preventative actions	3 (away from sun · shade · close eyes)	\$59
Disorientation Summary — REMEMBER count	6	\$60
1 G value	32 ft/s ² · 9.81 m/s ²	\$61
60° bank load factor	2 G	\$61.1
70° bank load factor	3 G	\$61.1
Aerobatic light aircraft positive G limit	+ 6 G	\$61.1
G-relief technique	Tense thigh + stomach · ease stick	\$61.2

DGCA-style probe questions

Try these without looking back

1. What illusion does blowing snow during a taxi-into-headwind create?
2. State the Somatogravic illusion on take-off. What is the dangerous reflex response?
3. List the SIX scenarios where outside references give a false impression.
4. Define auto-genesis. What may the pilot try to do that is dangerous?
5. State the three stages of the approach-and-landing visual task.
6. Define "Visual Angle".
7. Explain the narrow-runway illusion and the wide-runway illusion — both perception and outcome.
8. Define the Black Hole Effect. Give the typical environments. What is the result?
9. List FIVE triggers of a shallow-approach illusion.
10. List THREE triggers of a steep-approach illusion.
11. Explain "texture flow" and the inadvertent-speed-loss trap on final approach.
12. List FOUR ground-proximity height-assessment cues.
13. List the SIX DGCA-listed protective measures against illusions.
-  14. State the DGCA "master rule" for handling suspected disorientation — both IMC and VMC variants.
15. State the vibration band that contributes to airsickness. List SEVEN symptoms of motion sickness.
16. Define Head-Up Illusion. When does it typically occur? Why is the reflex response dangerous?
17. Define Head-Down Illusion. Why is the reflex response especially dangerous on final approach?
18. Define the Elevator Illusion for updraft and downdraft separately. What is each reflex response?
19. State the FOUR DGCA-listed triggers of False Horizon.
20. Name the three forms ofvection illusion with one-line definitions.
21. Define Geometric Perspective Illusion.
22. State the flicker-vertigo frequency band and list 4 possible reactions. Give 3 in-flight causes and 3 preventative actions.
23. List the SIX statements in the Disorientation Summary section.
24. State the numerical value of 1 G in both ft/s^2 and m/s^2 . State the load factor at 60° and 70° banks. State the positive G limit of a light aerobatic aircraft.
25. State the two DGCA-quoted counter-measures against adverse G effects.

Mnemonics — burn these into long-term memory

MNEMONIC — MASTER RULE "IMC = Instruments. VMC = horizon." Two words, two states, two actions. Every other illusion-defence rule reduces to these.

MNEMONIC — 6 OUTSIDE-REFERENCE TRAPS "TWHGSG" = Take-off (immediately after) · Water · Hilly terrain · Gently sloping terrain · Sloping cloud · Ground sloping on approach.

MNEMONIC — SHALLOW APPROACH TRIGGERS (5) "URFRH" = Up-slope · Runway narrow · Featureless terrain · Rain on screen · Haze. All cause the illusion of "too high".

MNEMONIC — STEEP APPROACH TRIGGERS (3) "DWB" = Down-slope · Wide runway · Bright lights. All cause the illusion of "too low".

MNEMONIC — GROUND PROXIMITY CUES (4) "SSWT" = Speed of ground objects · Size of lights · Width of runway · Texture of ground — all increase / change as you descend.

MNEMONIC — MOTION SICKNESS SYMPTOMS (7) "NH-V-PCHD" = Nausea + fear · Hyperventilation · Vomiting · Pallor · Cold sweating · Headache · Depression.

MNEMONIC — LINEAR-ACCELERATION ILLUSIONS "Accel-Up, Decel-Down" Forward acceleration = pilot feels nose UP → pushes forward = dive. Deceleration = pilot feels nose DOWN → pulls back = STALL on approach.

MNEMONIC — ELEVATOR ILLUSION "Updraft → push DOWN trap. Downdraft → pull UP trap." The pilot's reflex is always wrong — the illusion is opposite to reality.

MNEMONIC — BLACK HOLE "Black hole = short." No visual cues between aircraft and runway → pilot thinks "too high" → flies shallow → lands short. Killed many pilots over unlit water at night.

MNEMONIC — FLICKER VERTIGO BAND "4 to 20 — flicker hurts." 4–20 Hz flickering light can cause nausea, dizziness, LoC, even epilepsy-like fits. Defence: **turn away · shade · close eyes**.

MNEMONIC — LOAD FACTOR & BANK "60 → 2G, 70 → 3G" A 60° level turn = 2 G; a 70° level turn = 3 G; aerobatic light aircraft = +6 G limit.

MNEMONIC — G-RELIEF TECHNIQUE "Tense + Ease" = Tense thigh & stomach + Ease backward pressure on stick. The "AGSM" + stick-relax combination.

MNEMONIC — VECTION THREE "CLR — Circular · Linear · Roll" The three forms of self-motion illusion induced by moving surrounds.

CPL · ATPL · Human Performance & Limitations Aviation Physiology & Human Factors

Part 10 of the master study set — Effects of Increased G (Tunnel vision · Grey-out · Black-out · G-LOC) · 1.41 G at 45° · Factors degrading G-tolerance · Negative G & Red-out · Physical Characteristics · Exercise & BMI · Effects of Obesity · Nutrition · Vitamins · Minerals · Hypoglycemia · Gastric Distress & Contaminated Food

CHAPTER

Chapter 26 (the DGCA reference textbook)

INSTRUCTOR

Ghost Aviator

EXAM

DGCA CPL / ATPL — HPL

Join live classes for guided practice and doubt clearing.

Where Part 10 sits

Part 9 closed with the introduction to "G" forces — the 1 G value, the load factor at 60° (2 G) and 70° (3 G), the +6 G aerobatic limit, and the AGSM technique. Part 10 takes us into the



physiological cascade of positive-G effects (tunnel vision → grey-out → black-out), **1.41 G at 45° bank**, the **factors that degrade G-tolerance**, **Negative G and Red-out**, and then the **pilot-fitness block** — physical characteristics, BMI, obesity-related disease, nutrition, vitamins, minerals, hypoglycemia, gastroenteritis. Every DGCA exam draws several MCQs from this exact list.

Contents – Part 10

- | | |
|--|--|
| 1. §62 Effects of Increased G — the 6 symptoms | 11. — Effects of being badly overweight (13 conditions) |
| 2. — The cascade: weight → mobility → organs → tunnel → grey-out → black-out | 12. §68 Nutrition and Food Hygiene |
| 3. — Tilted-back seat — DGCA's quoted black-out mitigation | 13. — Sources of carbohydrates |
| 4. §63 1.41 G at 45° — the load-factor reference | 14. — Vitamins |
| 5. §64 Factors Adversely Affecting G-tolerance (six) | 15. — Minerals · the three majors (Calcium · Phosphorous · Iron) |
| 6. §65 Negative G & Red-out | 16. §69 Hypoglycemia |
| 7. §66 PHYSICAL CHARACTERISTICS — individual differences | 17. §70 Gastric Distress & Contaminated Foodstuffs |
| 8. §67 EXERCISE AND WEIGHT | 18. — Four major causes of food contamination |
| 9. — Body Mass Index (BMI) & normal ranges | 19. — Gastroenteritis · Pilot fitness implications · Symptoms |
| 10. — Exercise prescription & no appetite-suppressants | 20. Self-Check, Cheat-Sheet & Mnemonics |

DGCA-quoted — the six effects (memorise the order)

During increased "G" manoeuvres the pilot will feel the following effects:



1. Increase in body weight.
2. Mobility is impaired.
3. Internal organs displaced.
4. Onset of tunnel vision.
5. Grey out.
6. Possible blackout.

62.1 The Cascade — From Heaviness to Blackout

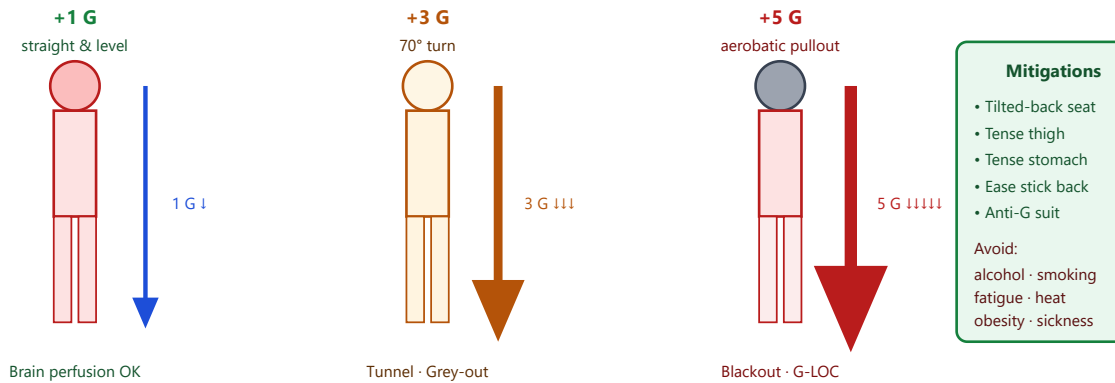
- 1 Body weight ↑
- 2 Mobility impaired
- 3 Organs displaced
- 4 Tunnel vision
- 5 Grey-out
- 6 Blackout

Why each effect happens in this order — physiological context



- **Effects 1–3 (heaviness, immobility, organ displacement)** are *mechanical*: with apparent weight multiplied by the load factor, limbs become difficult to lift, the head is forced down/sideways, and abdominal organs sag against the diaphragm.
- **Effects 4–6 (tunnel → grey → black)** are *cerebrovascular*: high positive G pulls blood downward, away from the head. Retinal arterial pressure falls first (cones in the fovea drain → tunnel vision = peripheral vision fails first), then central vision goes (grey-out), then cerebral perfusion fails (blackout / G-LOC).
- The ORDER of the six effects is the standard DGCA exam point — they happen in **this sequence as G increases**.

Why High Positive G Drains Blood from the Head



As positive G increases, the apparent gravity force on blood is multiplied. Cerebral perfusion fails progressively: tunnel vision → grey-out → blackout → G-LOC.

62.2 Tilted-Back Seat — the DGCA-quoted mitigation



DGCA-quoted

A tilted back seat can reduce the chance of a black-out during positive G-maneuvres.

Why a reclined seat helps



The taller the column of blood from the heart to the brain along the G-vector, the harder it is for the heart to pump against it. By **reclining the seat**, the vertical distance from the heart to the brain (measured along the seat-to-head axis, which is the G axis in a turn) is *reduced*. The blood column is shorter, the heart has less hydrostatic head to overcome, and cerebral perfusion is preserved at higher G loads. This is exactly why **fighter cockpits (F-16, etc.) recline the pilot's seat $\approx 30^\circ$** — to push the G-LOC threshold above where the airframe gives up first.

§ 63

1.41 G at 45° — the DGCA Reference

Number

DGCA-quoted — exact load-factor reference

 **1.41 G** is the acceleration experienced in a **LEVEL TURN** at **45° angle of bank**. In normal flying, angles of bank greater than this are not usually necessary.

Any physical disorder or immoderate consumption of alcohol or tobacco will reduce the body's tolerance to accelerations in excess of 1 G.

Load factor (n) vs bank angle in a level turn — $n = 1/\cos(\text{bank})$

Bank Angle	Load Factor (G)	Notes
0° (level flight)	1.00 G	Straight & level
15°	1.04 G	Shallow turn
30°	1.15 G	Standard rate turn (most light a/c)
45°	1.41 G	DGCA reference · upper limit of "normal flying"
60°	2.00 G	Steep turn · weight doubles
70°	3.00 G	Aerobatic turn
75°	3.86 G	—
80°	5.76 G	—
85°	11.5 G	Far beyond airframe / human limits

45° Maximum "normal" bank — DGCA quoted

1.41 G Load factor at 45° level turn

↓ tol. Reduced by disorder / alcohol / tobacco

Factors Adversely Affecting G-Tolerance

DGCA-quoted — the six factors (verbatim, in order)

1. Alcohol.
2. Smoking.
3. Fatigue.
4. Excessive heat.
5. Obesity.
6. Sickness.



Why each factor reduces G-tolerance

Factor	Physiological Effect
Alcohol	Vasodilation + dehydration + histotoxic hypoxia (§14) — blood pressure regulation degraded.
Smoking	5–8 % O ₂ -capacity loss + vasoconstriction + CO competition (§13) — less reserve when cerebral flow falls.
Fatigue	Cardiovascular reserve drops; muscle tone (for AGSM) is weakened; reaction time slows.
Excessive heat	Vasodilation for cooling + reduced blood volume from sweating → lower BP under G.
Obesity	Reduced cardiovascular fitness; abdominal fat reduces effectiveness of the AGSM straining manoeuvre.
Sickness	Dehydration, low BP, weakness — all the above multiplied.

Negative G & Red-out

DGCA-quoted — tolerance asymmetry



Most pilots can learn to tolerate moderate increases in positive "G", but many find even the smallest exposure to negative "G" to be unpleasant.

DGCA-quoted — when negative G is experienced in flight



During flight negative "G" is experienced if, after **pulling out of a steep dive**, the **control column is instinctively and firmly moved FORWARD** because the pilot might feel that he has his **nose too high in an attitude that may lead to a stall**.

DGCA-quoted — what negative G does to the body



Negative "G" manoeuvres **INCREASE** the flow of blood **TO THE HEAD**. Blood pressure there increases, the face becomes very **FLUSHED**, and the **EYES BULGE**. The combined effect of these symptoms causes what is described as a **"RED OUT"**.

To relieve symptoms select a normal flying attitude.

POSITIVE G → BLACK-OUT

- Blood pulled **away from** head, into legs
- Cerebral perfusion falls
- Cascade: tunnel → grey → black
- Can progress to G-LOC (G-induced LoC)
- **Tolerable up to ~6 G** with training (light aerobic limit)

NEGATIVE G → RED-OUT

- Blood pushed **into** the head
- Cerebral & ocular pressure rise
- Face flushes red, eyes bulge
- "Red-out" — vision tinged red
- **Even small exposures unpleasant**
- Mitigation: **return to normal flying attitude**

Why pilots are far worse at negative G than positive



Human cardiovascular anatomy is built for a 1 G "head-up" world. We have valves and reflexes that, under positive G, pump blood upward against gravity (the baroreceptor + sympathetic reflex). Under **negative G the body has NO compensatory mechanism** — blood floods the head, ocular and intracranial pressure rises, and small blood vessels in the eyes and brain can rupture. Even highly trained aerobatic pilots rarely tolerate more than **-3 G** sustained.

PHYSICAL CHARACTERISTICS — Individual Differences

DGCA-quoted

Differences among individuals are remarkable. Besides obvious physical differences (e.g., height, weight, age, sex, build, sitting height, functional reach, leg length, shoulder width, strength, co-ordination etc.), people also differ with respect to other traits like:



- Auditory threshold,
- Understanding,
- Vestibular (ear senses),
- Smell, touch, kin aesthetic (body feelings),
- G-tolerances, etc.

These traits are relatively stable over time, they differ across individuals, and they influence human behavior.

DGCA-medical implication

This is the underpinning for **cockpit ergonomics** and **pilot-selection standards**:



minimum/maximum sitting heights, reach envelopes for switches and rudder pedals, vision and hearing standards, etc. Each pilot is a different statistical sample — and the certification rules are designed so that the *typical* trained pilot can comfortably operate the aircraft, while extreme outliers may be screened out at the medical or flight-school stage.

EXERCISE AND WEIGHT

67.1 Body Mass Index (BMI)

DGCA-quoted — definition & formula



A person's Body Mass Index, or BMI, is simply a measure of a person's weight in relation to his height.

Body mass Index (BMI) = Weight (kgs) / Height² (m).



DGCA-quoted — normal BMI ranges

Normal BMI for MEN is **20 to 25** and WOMEN **19 to 24**.

$BMI = \text{kg/m}^2$ Weight in kg $\div$ height in m squared

20–25 Normal BMI for MEN

19–24 Normal BMI for WOMEN

Worked example



A pilot weighs 75 kg and is 1.78 m tall. $BMI = 75 / (1.78)^2 = 75 / 3.168 \approx 23.7$. Within normal range for men (20–25). ✓

67.2 Exercise Prescription & "No appetite suppressants"

DGCA-quoted — exercise prescription



Regular exercise is beneficial to general health, but the most efficient way to lose weight is by reducing **CALORIC CONSUMPTION**.

To reduce the risk of coronary artery disease, exercise should be done to **DOUBLE** the resting heart rate for at least **20 minutes, three times a week**.



DGCA-quoted — appetite suppressants prohibited

Pilots should **NOT** try to lose weight by taking appetite suppressants.

BEST WAY TO LOSE WEIGHT

Reduce calories

EXERCISE — TARGET HR

2× resting

EXERCISE — DURATION

≥ 20 minutes

EXERCISE — FREQUENCY

3 × per week

APPETITE SUPPRESSANTS FOR
PILOTS

Prohibited

67.3 Effects of Being Badly Overweight — 13 DGCA-quoted conditions

DGCA-quoted — verbatim list

Being **badly overweight INCREASES** a pilot's susceptibility to the following conditions:

1. Heart attack.
2. Hypertension.
3. Hypoxia at lower altitudes than normal.
4. General circulation problems.
5. Gout (swollen joints).
-  6. **Osteoarthritis** (a form of arthritis characterized by gradual loss of cartilage of the joints).
7. Diabetes.
8. The inability to tolerate G forces.
9. Problems with joints and limbs.
10. Decompression sickness.
11. Heavy sweating.
12. Chest infections.
13. **Varicose veins** (a vein that has become swollen and knotted as a result of faulty valves).

Cross-links — obesity is the pilot's "common enemy"

Note how this single list lights up almost every previous part of the chapter:

- Heart attack & hypertension & circulation problems → §9 / §15 / §61
-  • Hypoxia at lower altitudes → §10 / §13 (smoker comparison)
- Inability to tolerate G forces → §62 / §64
- Decompression sickness → §19 / §20 (DCS predisposing factor)

The DGCA examiner treats obesity as a *multiplier* of every other risk discussed in the chapter — which is why BMI screening is built into every Class-1 / Class-2 medical.

§ 68

Nutrition and Food Hygiene

DGCA-quoted — the empty-stomach rule

Never fly on an empty stomach. A balanced diet is the foundation of good health.



Join live classes for guided practice and doubt clearing.

68.1 Sources of Carbohydrates

DGCA-quoted

Sources of carbohydrates include:



- Grains,
- Vegetables,
- Nuts, and
- Fruit.

68.2 Vitamins

DGCA-quoted



Vitamins are organic substances required by the body to function properly. They help process other nutrients to form blood cells.

68.3 Minerals — the Three Majors

DGCA-quoted

Minerals are essential to many vital body processes — from building strong bones to transmitting nerve impulses.



The three major minerals include:

- Calcium — for healthy bones and teeth.
- Phosphorous — for body's chemical reaction and
- Iron — For Hemoglobin.

The Three Major Minerals — DGCA-Quoted Roles

Ca

CALCIUM

Healthy bones
& teeth

P

PHOSPHOROUS

Body's chemical
reactions

Fe

IRON

For
HAEMOGLOBIN

Join live classes for guided practice and doubt clearing.

The three DGCA-listed major minerals — Calcium (bones & teeth), Phosphorous (chemical reactions), Iron (haemoglobin → cross-link to §9.4 / §13).

§ 69

Hypoglycemia

DGCA-quoted — the brain needs fuel



Just as the brain needs oxygen to function, it also needs fuel to combine with the oxygen and produce energy. That fuel is **blood glucose**, which is carried by the bloodstream and easily passes the **blood-brain barrier**.

DGCA-quoted — the brain cannot store glucose

Glucose is a simple sugar and serves as an immediate source of energy for cells.



The brain **CANNOT STORE GLUCOSE** and requires a **CONTINUOUS SUPPLY** to function properly.

All foods containing carbohydrates will raise blood glucose levels.

DGCA-quoted — what hypoglycemia does to the pilot



Failure to eat properly may result in a shortage of glucose (hypoglycemia), which will produce **DECREMENTS IN COGNITIVE FUNCTIONING**.

Research has proved that hypoglycemia significantly compromises performance, resulting in **LONGER RESPONSE TIMES** and **LOWER SCORES** on cognitive tests.

Practical pilot rule



This is the physiological basis of the "**Never fly on an empty stomach**" rule (§68). A pilot who skipped breakfast — or who is on a crash diet — is operating with reduced cognitive performance. This becomes one of the DGCA-listed causes of **subtle incapacitation** (§27.3 — "Temporary hypoglycemia" is listed verbatim).

Gastric Distress and Contaminated Foodstuffs

70.1 Four Major Causes of Food Contamination

DGCA-quoted — verbatim

Major causes of food contamination are:



1. Unhygienic (i.e. unclean) food preparation.
2. Under cooked or stale meats.
3. Unwashed salads, fruit or vegetables.
4. Seafood and locally made ice-creams and mayonnaise.

70.2 Gastroenteritis — Pilot Fitness Rule

DGCA-quoted — pilot unfit even with medication

Pilots suffering from Gastroenteritis are **NOT FIT TO FLY**, even though they may be taking medicine which is relieving the symptoms.



Due to pressure differential, **TRAPPED GASES ESCAPE AT HIGH ALTITUDES** resulting in extreme discomfort and sickness.

Why altitude makes gastroenteritis worse — Boyle's Law again



Recall **Boyle's Law** from Part 1 — gas volume increases as pressure decreases. Gut gases that are tolerable at sea level can expand by $\sim 2\times$ by cabin altitude of 18,000 ft (where atmospheric pressure has halved, §19.2). For a gastroenteritis patient already producing excess gas, this expansion → severe abdominal pain, nausea, vomiting, sudden bowel motion — all of which incapacitate the pilot in the cockpit. Anti-diarrhoeal medication may mask the bowel symptoms on the ground but does nothing to prevent the gas-expansion mechanism in flight.

DGCA-quoted — Symptoms of Gastroenteritis



- Nausea
- Vomiting
- Abdominal Pain
- Diarrhea, and
- Loss of appetite.

§ R10

Self-Check, Cheat-Sheet & Mnemonics

GHOST AVIATOR

GHOST AVIATOR

Join live classes for guided practice and doubt clearing.

— Part 10

Master cheat-sheet — Part 10 numbers

Every numeric / regulatory / definitional fact from Part 10

Parameter	Exact Value / Fact	Where
Effects of increased G — number of effects (in order)	6 (weight ↑ · mobility ↓ · organs displaced · tunnel · grey · black)	\$62
Black-out mitigation	Tilted-back seat	\$62.2
Load factor at 45° level bank	1.41 G	\$63
Maximum "normal" bank angle	45°	\$63
Number of factors that reduce G-tolerance	6 (alcohol · smoking · fatigue · heat · obesity · sickness)	\$64
Negative G — typical trigger	Instinctive forward push after steep-dive pullout	\$65
Negative-G symptom name	RED-OUT	\$65
Red-out signs	Face flushed · eyes bulge · red vision	\$65
Red-out cure	Return to normal flying attitude	\$65
BMI formula	kg ÷ m²	\$67.1
Normal BMI — MEN	20 – 25	\$67.1
Normal BMI — WOMEN	19 – 24	\$67.1
Best weight-loss method	Reduce calories	\$67.2
Exercise — heart-rate target	2 × resting	\$67.2
Exercise — duration / frequency	≥ 20 min · 3 ×/wk	\$67.2

Join live classes for guided practice and doubt clearing.

Parameter	Exact Value / Fact	Where
Appetite suppressants — pilots	Do not use	\$67.2
Conditions associated with obesity	13 DGCA-listed	\$67.3
Empty-stomach rule	Never fly empty	\$68
Carbohydrate sources count	4 (grains · vegetables · nuts · fruit)	\$68.1
Three major minerals	Ca · P · Fe	\$68.3
Calcium — function	Bones & teeth	\$68.3
Phosphorous — function	Chemical reactions	\$68.3
Iron — function	Hemoglobin	\$68.3
Brain fuel	Blood glucose	\$69
Can brain store glucose?	NO – continuous supply needed	\$69
Hypoglycemia effects	↑ response time · ↓ cognitive scores	\$69
Food-contamination causes count	4	\$70.1
Pilot with gastroenteritis on meds	NOT fit to fly	\$70.2
Reason for fly-unfit (gastro)	Pressure differential – gas expansion	\$70.2
Gastroenteritis symptoms count	5	\$70.2

DGCA-style probe questions

Try these without looking back

1. List the SIX effects, in order, that a pilot experiences during increased "G" manoeuvres.
2. What single physical/mechanical action in the cockpit can reduce the chance of blackout during positive-G manoeuvres?
3. State the load factor experienced in a level turn at 45° angle of bank. Why is this number the upper limit of "normal flying"?
4. State the SIX DGCA-listed factors that reduce G-tolerance.
5. What in-flight scenario typically produces an exposure to negative G? What is the dangerous reflex that causes it?
6. Define "Red-out". List the three physical symptoms. State the corrective action.
7. State the BMI formula. Give the normal range for men and women.
-  8. What is the most efficient way to lose weight (DGCA-quoted)?
9. State the DGCA exercise prescription — target heart rate, duration, frequency.
10. Are pilots allowed to take appetite suppressants?
11. List at least eight of the thirteen conditions that being badly overweight predisposes a pilot to.
12. State the four DGCA-listed sources of carbohydrates.
13. Define vitamins. What do they help the body do?
14. Name the three major minerals and the role of each (one-liner).
15. What is the brain's fuel? Why is hypoglycemia particularly bad for cognitive functioning?
16. List the four major causes of food contamination.
17. Why is a pilot with gastroenteritis (even if on medication) considered unfit to fly?
18. List the five DGCA-listed symptoms of gastroenteritis.

Mnemonics — burn these into long-term memory

MNEMONIC — SIX G EFFECTS IN ORDER "WMO-TGB" = **W**eight ↑ · **M**obility ↓ · **O**rgans displaced · **T**unnel vision · **G**rey-out · **B**lackout. (Or remember the chain: heavy → can't move → guts sag → vision narrows → grey → black.)

MNEMONIC — BANK-ANGLE LOAD FACTORS "30→1.15 · 45→1.41 · 60→2.0 · 70→3.0" — the four numbers every DGCA candidate must know. **45° / 1.41 G** is the DGCA "normal flying" reference.

Join live classes for guided practice and doubt clearing.

MNEMONIC — G-TOLERANCE KILLERS (6) **"ASF-HOS"** = **A**lcohol · **S**moking · **F**atigue · **H**eat · **O**besity · **S**ickness. *(All six are also independent flight-fitness risks — they degrade G-tolerance on top of their other effects.)*

MNEMONIC — BLACK-OUT VS RED-OUT **" +G drops blood DOWN (black-out). -G shoves blood UP (red-out)."** Positive G blanks the screen black; negative G tints it red — face flushed, eyes bulging.

MNEMONIC — BMI **"Men 20-25, Women 19-24."** Body Mass Index = $\text{weight (kg)} \div \text{height (m)}^2$. Men one notch higher than women.

MNEMONIC — EXERCISE PRESCRIPTION **"2 × HR for 20 minutes, 3 times a week."** Double your resting heart rate, ≥20 min, 3 days/wk.

MNEMONIC — THREE MAJOR MINERALS **"Ca-P-Fe — Bones · Brain-chem · Blood."** Calcium = bones & teeth; Phosphorous = chemical reactions; Iron = haemoglobin.

MNEMONIC — CARBOHYDRATE SOURCES **"GVNF"** = **G**rain · **V**egetables · **N**uts · **F**ruit.

MNEMONIC — BRAIN-GLUCOSE RULE **"Brain can store nothing. Feed it continuously."** Never fly on an empty stomach — hypoglycemia is a DGCA-listed subtle-incapacitation cause.

MNEMONIC — FOOD CONTAMINATION (4) **"UUUS"** = **U**nclean prep · **U**ndercooked meats · **U**nwashed salads · **S**eafood / local ice cream / mayonnaise.

MNEMONIC — GASTROENTERITIS SYMPTOMS (5) **"NVAD-L"** = **N**ausea · **V**omiting · **A**bdominal pain · **D**iarrhoea · **L**oss of appetite. *Pilot grounded even on meds — gas expands at altitude.*

MNEMONIC — OBESITY MULTIPLIER

"Obesity = every risk + 1." The 13-item list in §67.3 hits heart, BP, hypoxia (lower), DCS, G-tolerance, joints, varicose veins, infections, sweating, diabetes & gout. It is the single biggest *compounding* health factor for pilots.

CPL · ATPL · Human Performance & Limitations Aviation Physiology & Human Factors

Part 11 — FINAL THEORY INSTALMENT | Sinus Blockage · Dental Pain (Barodontalgia) · Dehydration · Personal Hygiene · Common Ailments · Drugs & Self-Medication · Caffeine · Anaesthetics & Analgesics · Hypothermia · Toxic Hazards · Dangerous Cargo

CHAPTER

Chapter 26 (the DGCA reference textbook)

INSTRUCTOR

Ghost Aviator

EXAM

DGCA CPL / ATPL — HPL

SECTION

11 of 11 (theory) — closes the chapter

Closing the chapter — what Part 11 covers

This is the **final theory instalment** of the chapter. After this page in the source PDF, the chapter transitions into a **multiple-choice question bank** (pages 45 onward) — covered separately in a forthcoming Part 12 (model question + answer pack).



The topics in Part 11 are commonly under-emphasised in student notes but **regularly tested**: the **48–72 hr post-dental rule**, the **250–300 mg caffeine limit**, the **12 hr / 48 hr anaesthetic no-fly periods**, the **hypothermia temperature thresholds (98.6 / 95 / 82 °F)**, and the **six DGCA-listed toxic hazard sources** in the cockpit. Memorise the numbers; the language is examined verbatim.

Contents – Part 11 (Final Theory)

1. §71 Sinus Blockage
2. §72 Dental Pain (Barodontalgia)
3. — Six dental conditions
4. — 48–72 hr post-dental rule
5. §73 Dehydration
6. §74 Personal Hygiene
7. §75 Common Ailments
8. §76 Drugs and Self-Medication
9. — The DGCA "Aviation Medicine Specialist" rule
10. — Four reasons medicines disqualify
11. §77 Caffeine
12. §78 Anaesthetics & Analgesics
13. §79 Hypothermia
14. §80 Toxic Hazards (6 DGCA sources)
15. §81 Dangerous Cargo
16. Self-Check, Cheat-Sheet & Mnemonics
17. Closing Master Cross-Reference Summary

§ 71

Sinus Blockage

DGCA-quoted

If the sinuses are congested, then air trapped there can also produce a painful condition. This sinus block occurs most frequently during DESCENT.



Slowing or stopping the descent until the pressure inside the sinus equalizes with the external pressure is the best course of action once this condition occurs.

Of course, NOT FLYING when the pilot has a congested sinus is even better.

Why descent — the same one-way-valve problem as ears (§38.2)

The sinuses are air-filled cavities in the skull (frontal, maxillary, ethmoid, sphenoid) that normally drain through narrow ostia into the nasal cavity. On **climb**, sinus air *expands* and pushes outward — easy. On **descent**, ambient pressure rises and sinus air must *contract* by drawing more air in from the nose. If the ostium is blocked by mucus/inflammation (cold, hay fever, sinusitis), incoming air cannot enter — a vacuum forms in the sinus → severe pain over the forehead, cheeks or behind the eyes ("sinus squeeze" / barosinusitis).

Mitigation in flight: stop or slow the descent and allow time for pressure to equalise. **Prevention on the ground:** if you have a head cold, don't fly.



DGCA-quoted — definition

Reduction in atmospheric pressure may also result in BARODONTALGIA — tooth pain.

72.1 Six Dental Conditions That Cause Barodontalgia

DGCA-quoted — verbatim list

This may be caused by a number of dental conditions including:

1. (a) Dental disease,
2. (b) Dental caries (a cavity),
3. (c) Defective tooth restoration,
4. (d) Pulpitis,
5. (e) Cysts, and
6. (f) Impacted teeth.



Mechanism — gas trapped in tooth cavities + Boyle's Law

A small gas pocket under a filling, in a decayed pulp, or inside a sealed cyst **expands** as cabin altitude rises (Boyle's Law again — §2.1). The expanding gas pushes outward against the tooth nerve → sharp, throbbing pain that becomes excruciating at typical airline cabin altitude (6,000–8,000 ft). It often resolves on descent — but if the affected tooth is fractured by the expansion, the pain persists on the ground.



72.2 The 48–72 Hour Post-Dental Rule

DGCA-quoted — the no-fly rule

This condition may be avoided by NOT FLYING for **48 – 72 hours** following a major dental work.



As with the other problems associated with lower atmospheric pressure, **descending to a lower altitude (and correspondingly higher atmospheric pressure) is often the best antidote.**

48–72_{hr} No-fly window after major dental work

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6 DGCA-listed dental causes of barodontalgia

↓ alt In-flight cure — descend to higher-pressure altitude

§ 73

Dehydration

DGCA-quoted



Besides watching what and when they eat, **pilots should also be aware of the effects of dehydration. Low fluid intake and dehydration have ADVERSE EFFECTS ON COGNITIVE FLIGHT PERFORMANCE of pilots.**

Cross-links — dehydration is everywhere in this chapter

Dehydration has already been flagged repeatedly in earlier parts:

- **§14 (Alcohol)** — alcohol is a diuretic; "masked hangover" includes dehydration.
- **§23 (Humidity)** — cabin RH below 20 % drives over-all dehydration if fluid intake is inadequate; avoid coffee/tea (diuretics).
- **§28.2 (Fainting)** — "standing up quickly after prolonged sitting especially when HOT or DEHYDRATED" is the first DGCA cause of faint.
- **§64 (G-tolerance)** — excessive heat (sweating + lost blood volume) reduces tolerance.

Practical pilot rule: drink ~250 ml of water every hour during a long sector, regardless of thirst.

§ 74

Personal Hygiene

DGCA-quoted



A high standard of personal hygiene must be practiced if the body is to remain healthy and free from infection.

Practical implications for crew

- **Frequent hand washing** — particularly before meals and after lavatory use; crew in pressurised, low-humidity cabins are at elevated risk of respiratory infections.
- **Oral hygiene** — directly reduces barodontalgia risk (§72) by reducing the prevalence of caries.
- **Skin care** — low humidity dries skin; lotion/moisturiser reduces cracking that can introduce infection.
- **Foot hygiene & well-fitting shoes** — long sectors with feet on rudder pedals make foot-fungal infections more common in crew.

§ 75

Common Ailments

DGCA-quoted — verbatim



The in-flight environment can increase the severity of symptoms which may be minor whilst on the ground. If there is any doubt whatsoever in a pilot's mind about his fitness to fly, he should **STAY ON THE GROUND**.

The "minor on ground, major in flight" principle



A head cold is a nuisance on the ground; in the air it becomes **otic barotrauma + sinus block**. A gastric upset on the ground is a meal-skip; in the air the trapped gases **expand and incapacitate** (§70.2). A mild headache becomes incapacitating under cabin vibration and G-load. The DGCA-codified rule for any doubt is binary: **stay on the ground**. *The cost of a cancelled flight is always less than the cost of a sick pilot in command.*

§ 76

DRUGS AND SELF-MEDICATION

76.1 The Aviation-Medicine-Specialist Clearance Rule

DGCA-quoted — the absolute rule



It is absolutely essential that pilots **DO NOT FLY** as part of the operating crew of an aircraft when taking drugs or medication, **UNLESS THEY HAVE BEEN CLEARED TO DO SO BY AN AVIATION MEDICINE SPECIALIST**.

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DGCA-quoted — risks of self-prescribed medication

A pilot who flies on **self-prescribed medication** runs the risk of:



- Suffering **side effects**, and
- Faces the **hazards associated with the underlying illness in the in-flight environment** which can **make the symptoms of any illness much more debilitating than they might be on the ground**.

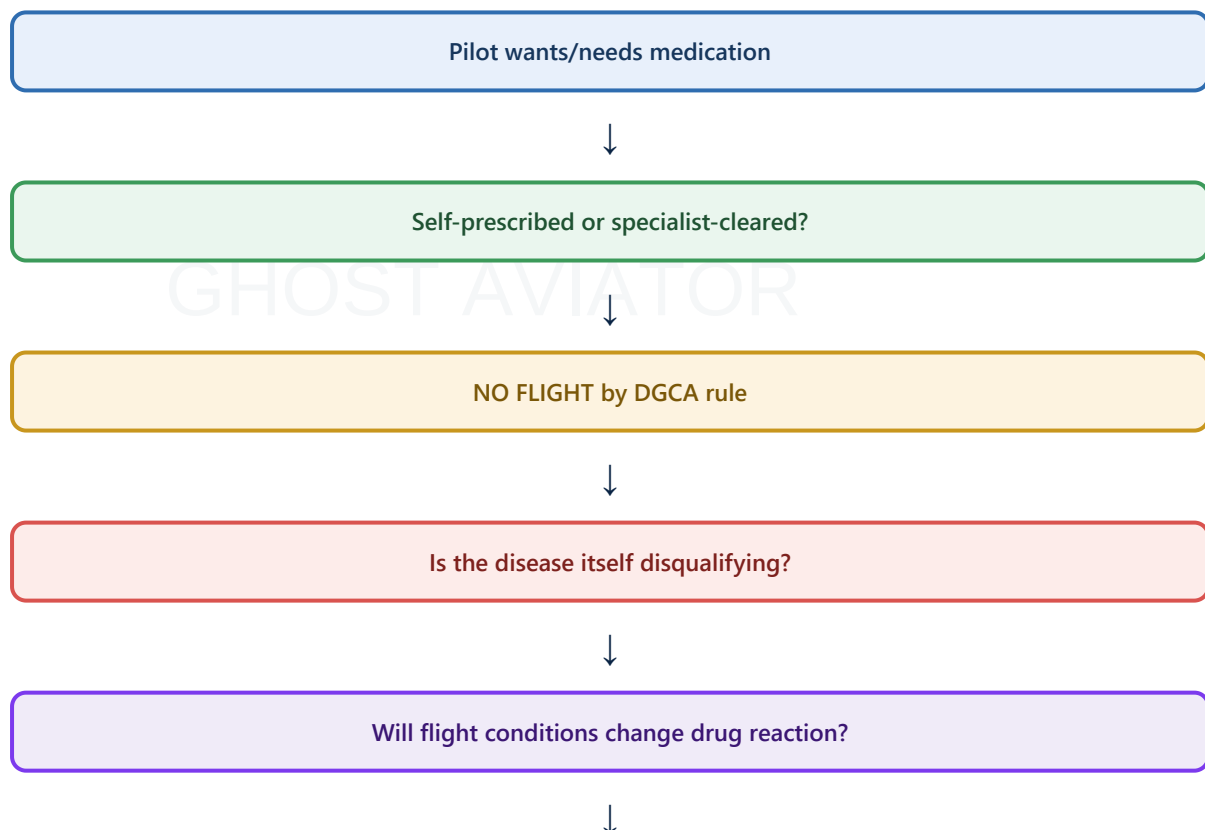
76.2 Four Reasons Medicines Have Flight-Qualification Consequences

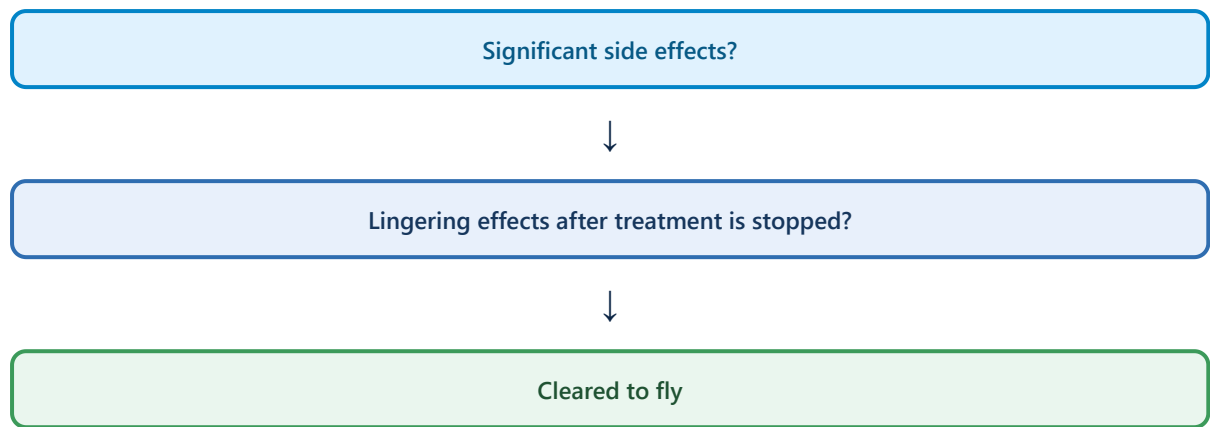
DGCA-quoted — verbatim four reasons

The consumption of **medicines or other substances** may have consequences on qualification to fly for the following reasons:



1. The disease requiring a treatment may be cause for disqualification.
2. Flight conditions may modify the reactions of the body to a treatment.
3. Drugs may cause adverse side effects impairing flight safety.
4. The effects of medicine do not necessarily immediately disappear when the treatment is stopped.





§ 77

CAFFEINE

DGCA-quoted — caffeine as a drug



Caffeine is probably the most widely used drug in the world. It can easily lead to **ADDICTION**.

Caffeine is present in coffee, tea, cocoa, chocolate, and fizzy drinks such as cola.

DGCA-quoted — recommended maximum daily intake



The recommended maximum caffeine intake per day is approximately **250 – 300 mg** corresponding to **2 – 3 cups of coffee**.

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Approximate caffeine content of common beverages

Beverage	Caffeine (mg)	Notes
Filter coffee (250 ml cup)	~ 100 – 120 mg	2–3 cups → DGCA daily max
Espresso (single shot, 30 ml)	~ 60 – 80 mg	—
Black tea (250 ml cup)	~ 40 – 60 mg	Lower than coffee
Cocoa / hot chocolate	~ 5 – 15 mg	Plus theobromine
Cola (330 ml can)	~ 30 – 45 mg	—
Energy drink (250 ml)	~ 80 – 150 mg	Often exceeded
Dark chocolate (50 g)	~ 30 mg	—

250–300_{mg} DGCA max recommended daily caffeine

2–3 Cups of coffee = approximate DGCA limit

⚠ Caffeine is addictive — DGCA word

Why the DGCA bothers to set a caffeine limit

Caffeine is a CNS stimulant. In moderate doses it sharpens alertness — useful on long sectors. In excess it:



- Increases heart rate and blood pressure (interacts with §15 hypertension & §43 cardiovascular reserve under G).
- Is a **diuretic** (interacts with §23 humidity / §73 dehydration).
- Disrupts sleep — undermining the very alertness it was meant to provide; classic withdrawal cycle.
- Causes tremor & anxiety at high doses — degrades fine motor control.

The "2-3 cups" guidance is the dose that keeps you alert without these costs.

Anaesthetics & Analgesics

DGCA-quoted — no-fly periods

A pilot should NOT fly for at least:



- **12 hours** after a **LOCAL** anaesthetic, and
- **48 hours** following a **GENERAL** anaesthetic.

The more potent forms of **ANALGESICS** (pain killers) may produce a significant deterioration in human performance.

12_{hr} After **LOCAL** anaesthetic — no fly

48_{hr} After **GENERAL** anaesthetic — no fly

⚠ Strong analgesics — performance deterioration

Cross-link — adds to the "wait-before-flying" master table

You now hold these wait-before-flying numbers in long-term memory:



- **12 hr** — after rapid decompression (§20.4); after local anaesthetic (§78)
- **24 hr** — after alcohol (§14.1); after diving (§21)
- **48 hr** — after blood donation (§17); after general anaesthetic (§78)
- **48–72 hr** — after major dental work (§72.2)

The DGCA examiner pulls these numbers in MCQs — match the event to the number.

Hypothermia

DGCA-quoted — temperature thresholds (in Fahrenheit, source PDF)

Normal body temperature averages **98.6 °F**.



With **hypothermia**, the core temperature drops below **95 °F**.

In **SEVERE hypothermia**, core body temperature can drop to **82 °F or lower**.

98.6 °F NORMAL

37 °C — baseline core temperature

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< 95 °F HYPOTHERMIA

≈ 35 °C — onset of impaired ability

≤ 82 °F SEVERE

≈ 28 °C — life-threatening

DGCA-quoted — what hypothermia does

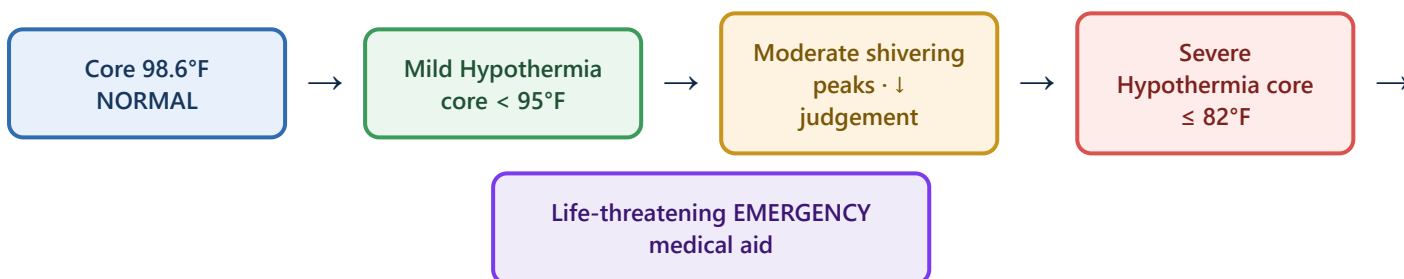
Hypothermia AFFECTS PHYSICAL AND MENTAL ABILITIES.

Shivering makes it possible to combat the cold to a certain extent but USES UP A LOT OF ENERGY.



In a PROLONGED exposure, shivering will tend to CEASE, and be followed by the ONSET OF APATHY.

Hypothermia is a potentially LIFE-THREATENING condition that needs EMERGENCY MEDICAL ATTENTION.



Operational relevance — survival in cold ditching / mountain crash



For commercial pilots flying over cold water (North Atlantic, Bering Sea) or high-terrain routes, hypothermia is the second-most-common post-ditching cause of death (after drowning). Survival suits, life rafts with thermal protection, and immersion-suit drills exist precisely because **cold water kills faster than the absence of food or water**. The "**cessation of shivering + apathy**" is the danger sign that mild hypothermia is becoming severe.

DGCA-quoted — opening

Even MILD toxic effects can degrade a pilot's performance and lead to an accident.



Prolonged exposure to toxic influences can damage a person's general health.

Anyone who has been exposed to any toxic hazard should seek **MEDICAL ASSISTANCE AS SOON AS POSSIBLE**.

DGCA-quoted — six toxic-hazard sources (verbatim)

The following materials may produce toxic hazards:



1. Furnishings and Baggage.
2. Acetone and Turpentine.
3. Fuels, Lubricants and propellants.
4. Anti-icing Fluid.
5. Fire Extinguishing Agents.
6. Battery Fumes.

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#	Source	Typical Toxin / Mechanism
1	Furnishings and Baggage	Off-gassing of plastics, adhesives, treated fabrics — VOCs, formaldehyde. Also packaged chemicals in baggage holds that leak in flight.
2	Acetone and Turpentine	Solvents — CNS depressants on inhalation. Respiratory irritation, headache, dizziness.
3	Fuels, Lubricants and Propellants	Jet-A vapours, oil mists, hydraulic fluid mists. Skin irritation, respiratory irritation, possible CNS effects.
4	Anti-icing Fluid	Glycols (mono-/di-ethylene glycol) — toxic if ingested, irritant if inhaled as mist.
5	Fire Extinguishing Agents	Halons / their replacements — high concentrations displace oxygen, can produce hypoxia (§10). Some thermal decomposition products are corrosive.
6	Battery Fumes	Sulphuric acid vapours (lead-acid), or KOH (Ni-Cd), or lithium-fire smoke. Strong respiratory irritants, possibly corrosive.

§ 81

Dangerous Cargo

DGCA-quoted — verbatim



Pilots must be aware that they must NOT carry certain defined items on board their aircraft. Such items are referred to as DANGEROUS CARGO because of the possibility that their discharge, spillage or breakage may endanger the aircraft and/or crew in flight or on the ground.

The regulatory backbone — DGR / ICAO TI / 49 CFR 175

The Indian DGCA enforces dangerous-goods carriage rules in line with **ICAO Technical Instructions for the Safe Transport of Dangerous Goods by Air** and the **IATA Dangerous Goods Regulations (DGR)**. The nine UN dangerous-goods classes are:

1. **Explosives** (ammunition, fireworks)
2. **Gases** (compressed, liquefied, dissolved — including aerosols)
3. **Flammable liquids** (fuel, paint, solvents)
4. **Flammable solids · spontaneously combustible · dangerous when wet**
5. **Oxidizers · organic peroxides**
6. **Toxic & infectious substances**
7. **Radioactive material**
8. **Corrosives** (acids, alkalies)
9. **Miscellaneous** (asbestos, lithium batteries, magnetised material, dry ice)

(For full HPL/exam preparation, learn these nine classes — DGCA RTR & DGR examinations routinely ask which class a given item belongs to and whether it is forbidden, restricted, or permitted in checked/cabin baggage.)

Why this section ends Chapter 26

The chapter has built up systematically: **atmosphere** → **body systems** → **environmental stressors** → **orientation & illusions** → **fitness & diet** → **drugs & toxins** → **dangerous cargo**. The last paragraph closes by reminding the pilot that the threat to the aircraft does not come only from the pilot's own body, but also from **what is loaded into the cabin and cargo holds**. The pilot's command authority extends to ensuring forbidden items are not on board — the pre-flight cargo manifest is a flight-safety document, not paperwork.

§ R11

Self-Check, Cheat-Sheet & Mnemonics

— Part 11

Master cheat-sheet — Part 11 numbers

Every numeric / regulatory / definitional fact from Part 11

Parameter	Exact Value / Fact	Where
Sinus blockage — most common phase	DESCENT	\$71
Sinus blockage — best in-flight action	Slow or stop the descent	\$71
Sinus blockage — best prevention	Don't fly when congested	\$71
Barodontalgia definition	Tooth pain from pressure reduction	\$72
Dental causes of barodontalgia — count	6	\$72.1
Post-dental no-fly window	48 – 72 hours	\$72.2
Dental pain in-flight antidote	Descend to higher pressure	\$72.2
Dehydration effect on pilot	Adverse cognitive flight performance	\$73
Personal hygiene standard	HIGH – for infection-free body	\$74
If any doubt about fitness to fly	Stay on the ground	\$75
Self-medication for pilots	Prohibited without Aviation Med Specialist clearance	\$76.1
Reasons medicines disqualify — count	4	\$76.2
Most widely used drug worldwide	Caffeine	\$77
Caffeine sources — DGCA list	Coffee · Tea · Cocoa · Chocolate · Fizzy/Cola	\$77

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Parameter	Exact Value / Fact	Where
Recommended max caffeine/day	250 – 300 mg	\$77
That equates to	2 – 3 cups of coffee	\$77
No-fly after LOCAL anaesthetic	≥ 12 hours	\$78
No-fly after GENERAL anaesthetic	≥ 48 hours	\$78
Strong analgesics — effect	Significant performance deterioration	\$78
Normal body temperature	98.6 °F	\$79
Hypothermia threshold	< 95 °F	\$79
Severe hypothermia threshold	82 °F or lower	\$79
Shivering's role	Combats cold; uses much energy	\$79
Late-stage hypothermia sign	Shivering CEASES → APATHY	\$79
Toxic-hazard sources — count	6	\$80
Action after exposure to toxic hazard	Seek medical assistance ASAP	\$80
UN dangerous-goods classes (regulatory)	9	\$81

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DGCA-style probe questions

Try these without looking back

1. During which phase of flight does sinus block most frequently occur? What is the best in-flight action? What is the best preventative?
2. Define barodontalgia. List the six dental conditions that can cause it.
3. State the DGCA no-fly window after major dental work. What in-flight action gives relief?
4. What effect does dehydration have on a pilot's performance?
5. State the DGCA "stay-on-the-ground" rule regarding common ailments.
6. State the DGCA absolute rule on drugs/medication. Who must clear a pilot for flight while on medication?
7. State the FOUR DGCA-listed reasons medicines have flight-qualification consequences.
8. State the recommended maximum daily caffeine intake (both mg and cups of coffee). List the five sources of caffeine in the DGCA list.
9. State the no-fly periods after LOCAL and GENERAL anaesthetics. What does the DGCA say about strong analgesics?
10. State (i) normal body temperature, (ii) hypothermia threshold, (iii) severe hypothermia threshold — all in °F.
11. Describe what happens to shivering and consciousness as hypothermia progresses to severe.
12. List the SIX DGCA-listed toxic-hazard sources in aviation.
13. State the DGCA "even mild toxic effects..." warning and the recommended action after toxic exposure.
14. Define Dangerous Cargo. Why is it the chapter-closing topic?
15. State the four "wait-before-flying" rules in this chapter — diving / RD / blood donation / alcohol / general anaesthetic / dental — match each to its hours.

Mnemonics — burn these into long-term memory

MNEMONIC — SINUS & EAR: SAME PROBLEM, SAME PHASE "Descent destroys." Both ear (§38) and sinus block (§71) happen worst on descent. Both: slow/stop descent — or better, don't fly congested.

MNEMONIC — SIX DENTAL CAUSES "D-D-D-P-C-I" = **D**ental disease · **D**ental caries · **D**efective restoration · **P**ulpitis · **C**ysts · **I**mpacted teeth.

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MNEMONIC — WAIT-BEFORE-FLYING MASTER LIST**"12 - 12 - 24 - 24 - 48 - 48 - 48-72"** hr

after:

- **12 hr** — Rapid Decompression
- **12 hr** — Local anaesthetic
- **24 hr** — Alcohol (bottle-to-throttle)
- **24 hr** — Diving
- **48 hr** — Blood donation
- **48 hr** — General anaesthetic
- **48-72 hr** — Major dental work

MNEMONIC — FOUR REASONS MEDICINES DISQUALIFY**"DSDL"** = **D**isease itself disqualifies ·**S**ide effects · **D**rug-flight interaction · **L**ingering effect after stopping treatment.**MNEMONIC — CAFFEINE LIMIT****"250-300 mg, 2-3 cups."** Most widely used drug. Addictive.Sources: **C**offee · **T**ea · **C**ocoa · **C**hocolate · **C**ola.**MNEMONIC — HYPOTHERMIA THRESHOLDS (°F)****"98.6 normal · <95 hypo · ≤82 severe."**Late-stage sign: **shivering CEASES + apathy**. Hypothermia is life-threatening — emergency medical aid required.**MNEMONIC — SIX TOXIC-HAZARD SOURCES****"F-A-F-A-F-B"** = **F**urnishings & baggage ·**A**cetone & turpentine · **F**uels/lubricants/propellants · **A**nti-icing fluid · **F**ire extinguishing agents ·
Battery fumes.**MNEMONIC — COMMON-AILMENTS RULE****"In doubt? On ground."** If any doubt about fitness

to fly, stay on the ground.



Closing Master Cross-Reference

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Summary

What the chapter has built

You have now completed the theoretical content of **Chapter 26 — Aviation Physiology and Human Factors (the reference textbook, 16th Edition)**. The chapter has covered, in order: atmospheric physics & gas laws → physiological zones → respiratory & circulatory systems → hypoxia & CO poisoning & hyperventilation → smoking · alcohol · blood pressure · baroreceptor reflex · blood donation → cabin pressurisation · TUC · decompression sickness & the bends · flying after diving → cockpit environment (humidity · temperature · vibration · glare) · incapacitation in flight · fits & faints → vision & the eye (anatomy · acuity · dark adaptation · defects · sunglasses) → colour vision · the ear · balance mechanism · orientation factors → spatial disorientation & illusions → G-forces · physical characteristics · BMI & obesity · nutrition · hypoglycaemia · gastric distress → sinus & dental · dehydration · drugs · caffeine · anaesthetics · hypothermia · toxic hazards · dangerous cargo. **That is the full HPL syllabus for DGCA CPL / ATPL.**



Master "Wait-Before-Flying" reference

The full DGCA "Wait-Before-Flying" rules in this chapter

Event	Minimum Wait	Source
After rapid decompression	12 hr	§20.4 (Part 5)
After local anaesthetic	12 hr	§78 (Part 11)
After alcohol consumption (bottle-to-throttle)	24 hr	§14.1 (Part 4)
After diving (compressed air, >30 ft)	24 hr	§21 (Part 5)
After blood donation	48 hr	§17 (Part 5)
After general anaesthetic	48 hr	§78 (Part 11)
After major dental work	48 – 72 hr	§72.2 (Part 11)

Master "Pressure-Altitude" reference

Key altitude thresholds across the chapter

Threshold Event	Altitude	Source
ISA SL pressure	1013.25 hPa	§3 (Part 1)
Maximum altitude without O ₂ — no efficiency loss	8,000 ft	§19.1 (Part 5)
Maximum cabin altitude (commercial pressurised)	8,000 ft	§19.4 (Part 5)
Typical commercial cabin altitude at FL300	≈ 6,000 ft	§19.4 (Part 5)
Smoker's effective physiological altitude	≈ 7,000 ft cabin = 10,000 ft physiology	§13 (Part 4)
Low DCS risk altitude — below	10,000 ft	§19.1 (Part 5)
Physiologically Deficient Zone begins	12,000 ft	§5 (Part 1)
Atmospheric pressure halved at	18,000 ft	§19.2 (Part 5)
Unpressurised → bends threshold	> 25,000 ft	§19.2 (Part 5)
Armstrong's line / water boiling at body temp	63,000 ft	§5 (Part 1)
Partial Space-Equivalent Zone	50,000 ft → 120 nm	§5 (Part 1)
Total Space-Equivalent Zone	> 120 nm	§5 (Part 1)
Dark adaptation impaired above cabin altitude	5,000 ft	§31.2 (Part 7)

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END OF THE THEORY OF CHAPTER 26

You have now covered every page of theoretical content (pages 1 – 44 of the source PDF).

The chapter continues with a comprehensive MCQ Question Bank starting at page 45.

Part 12 (forthcoming) will reproduce that question bank with full DGCA-style worked answers and chapter cross-references.

DGCA Ground School — Air Regulations • Chapter 25: Aviation Physiology & Human Factors
Study notes prepared by **Ghost Aviator** for CPL / ATPL examinees • All 11 parts combined • For instructional use.

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