

Human Performance & Limitations · Module E — The Senses

The Eye

Chapter 11 — The pilot's primary instrument: how the eye focuses light like a camera, the retina's rods and cones, and the sharpness (visual acuity) the examiner tests.

BOOK

Human Performance & Limitations

AUTHOR

Ghost Aviator

EXAM

DGCA CPL / ATPL — HPL

CHAPTER

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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).**

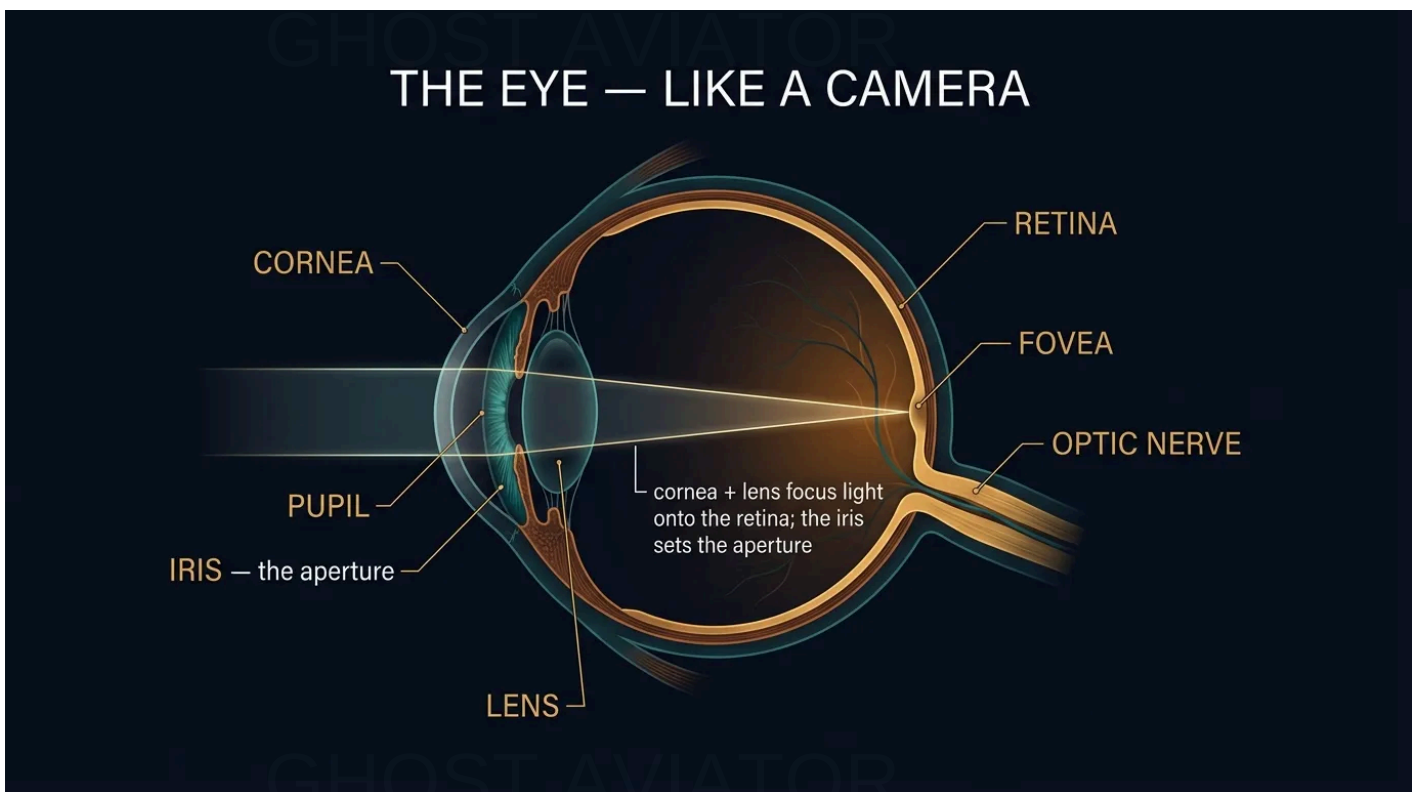


Figure 11.1 — The eye as a camera: the cornea and lens focus light onto the retina; the iris sets the aperture.

29.1 The Cornea, Iris & Pupil, Lens

THE CORNEA — DGCA-QUOTED

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

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

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**.

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THE RETINA — RODS & CONES

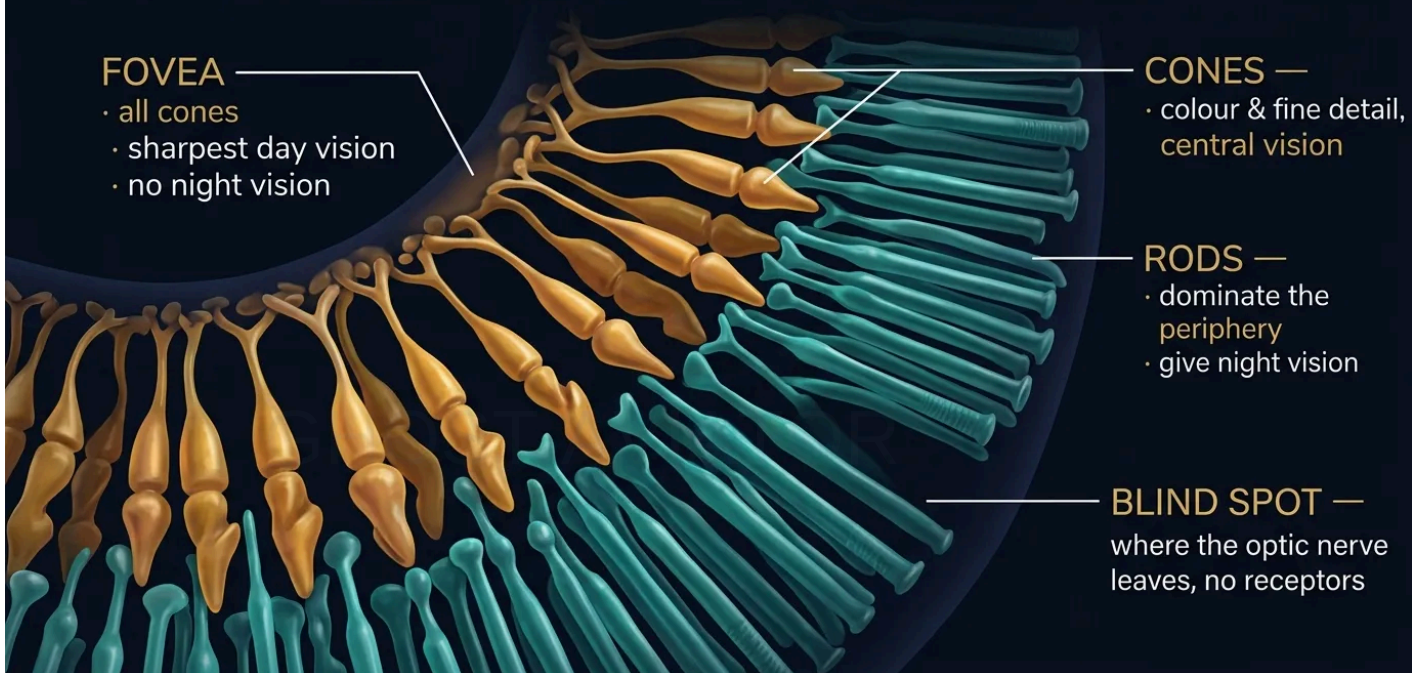


Figure 11.2 — The retina: the fovea is all cones (sharp day vision, no night vision); rods dominate the periphery and give night vision.

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.

✦ END OF CHAPTER 11 ✦

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