CPL Theory
Human Factors (HUF)

CHUF 3 – Vision & Illusions

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3. Disclaimer

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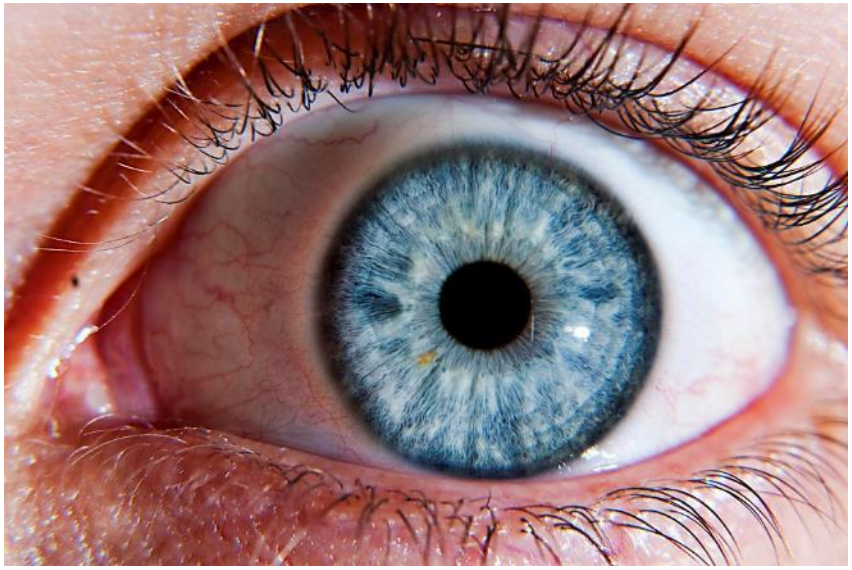
CHUF 3 – Vision & Illusions

THE EYE

The Eye

- Our eyes are like natural cameras – they provide us with a visual image of our environment



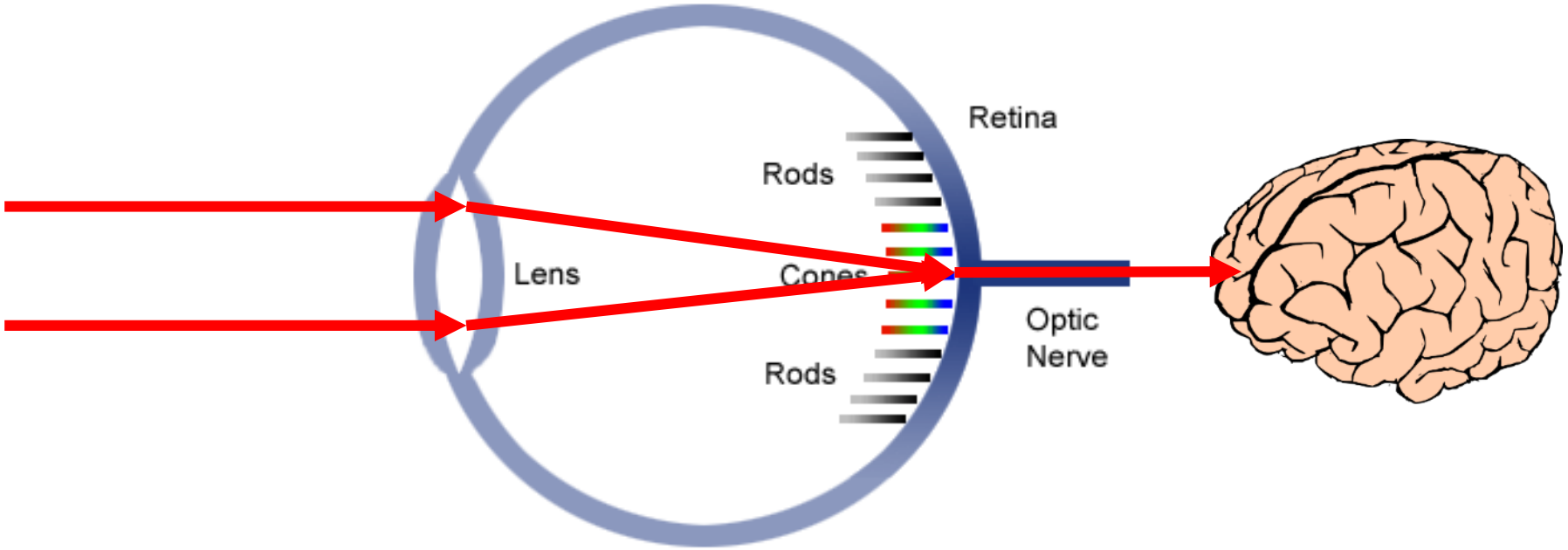
The Eye – Basic Function

- The basic process is:

1. Eye collects light rays reflected from objects

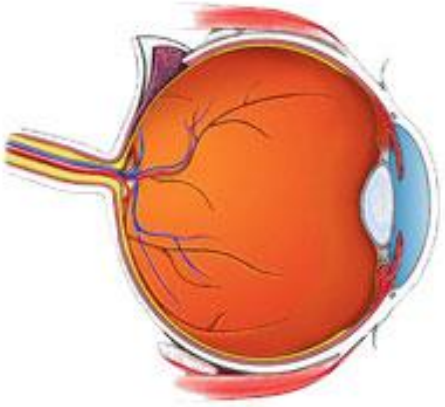
2. The lens and cornea focus these rays onto a screen (the retina)

3. The retina converts this into electrical signals which are sent to the brain via the optic nerve

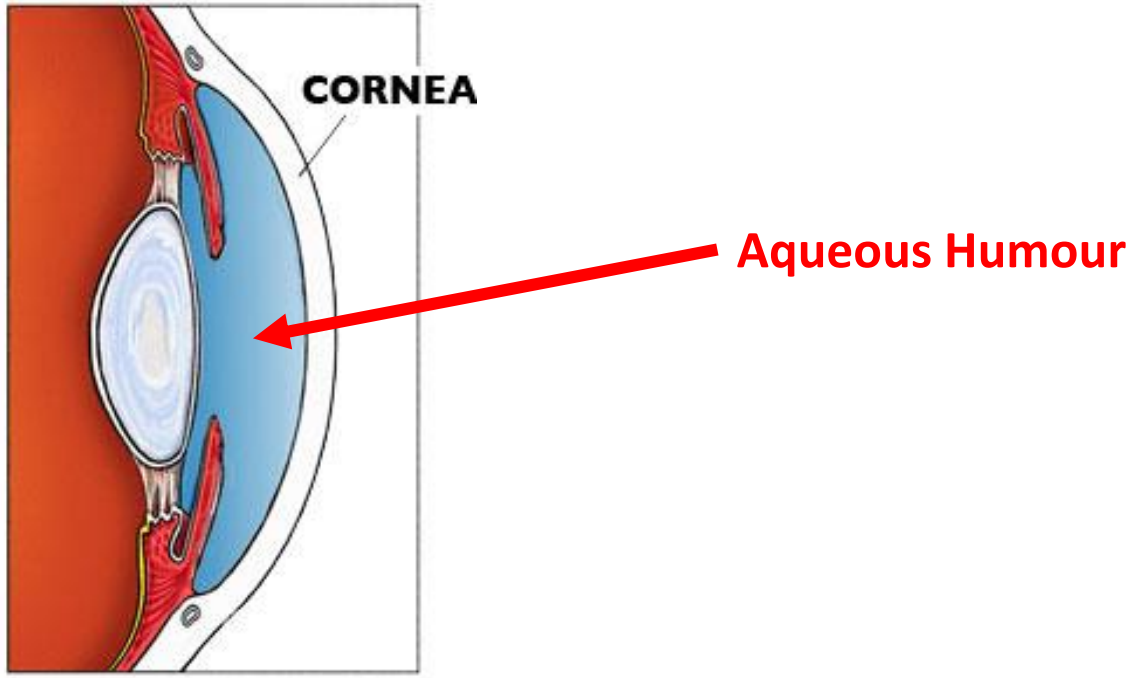


The Eye - Cornea

- The **cornea** is a **transparent layer** covering the **front** of the eye



Cut-away view of the eye



- It acts like a wind shield, **protecting the eye** from intrusions
- It also helps the lens to **focus light rays** onto the retina
- The cornea is held in a specific shape by a transparent fluid called **aqueous humour**

The Eye - Iris

- The **iris** is the **coloured** part of the eye
- It **changes its shape** according to the **intensity** of light
- This causes the pupil to expand or contract, allowing more or less light to enter through to the lens:

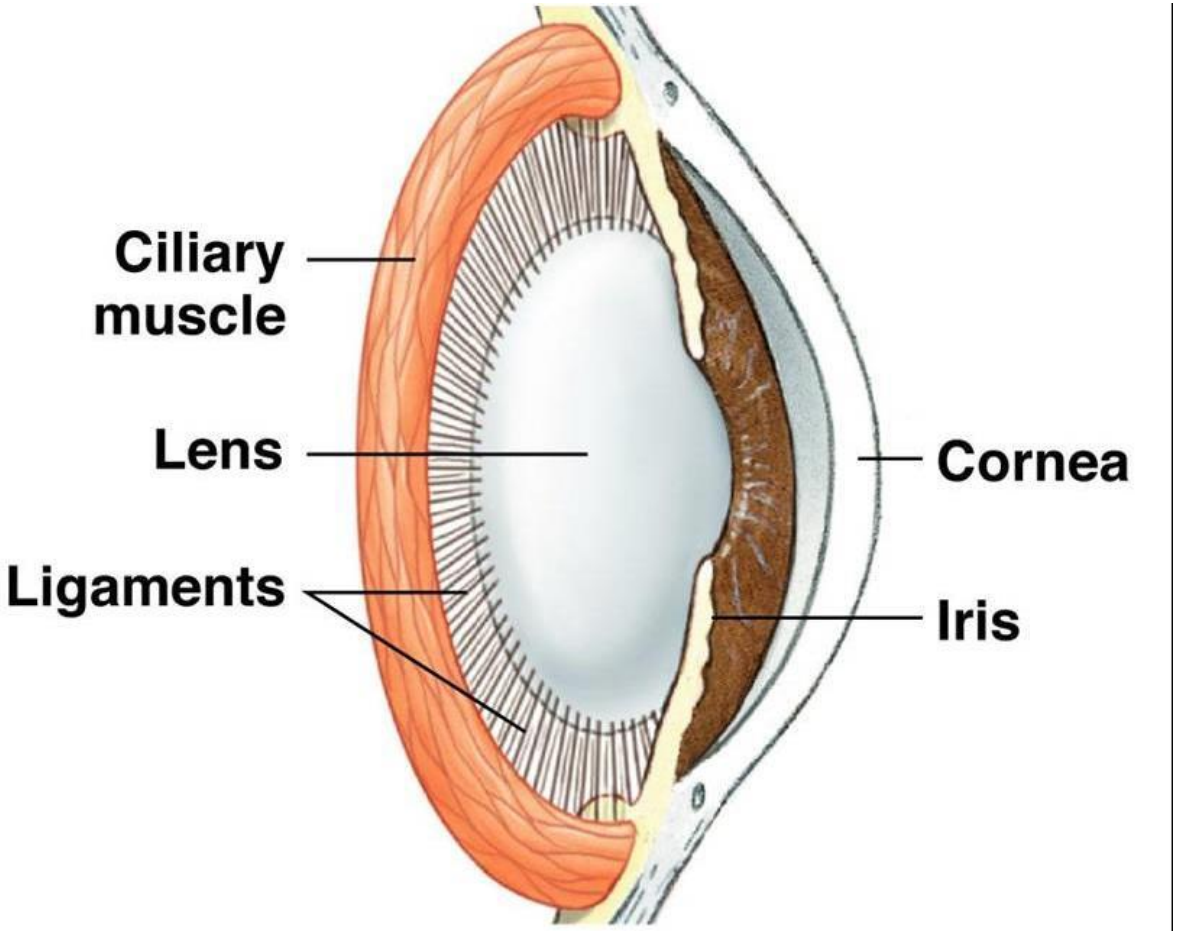
1. In bright light, the iris expands to cover most of the lens

2. In dim light, the iris contracts and the pupil has a wide dilation to allow more available light to enter the eye

The Eye – Ciliary Muscles

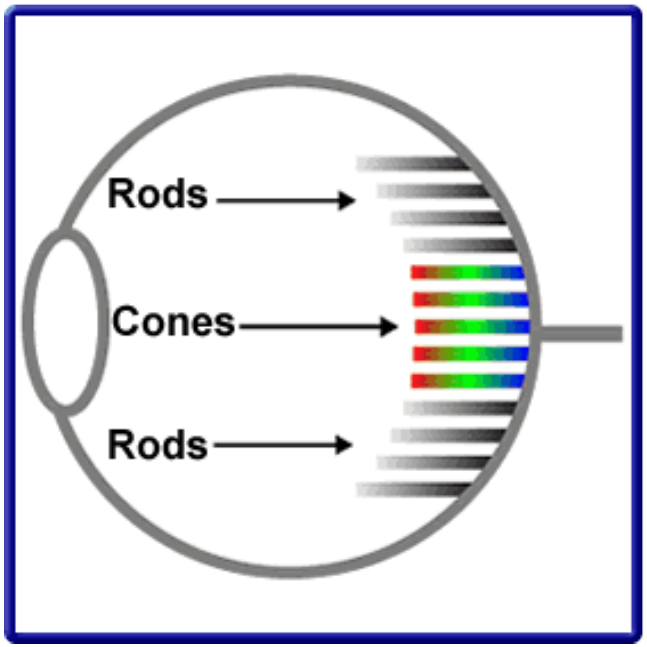
- The **ciliary muscles** alter the **shape of the lens**

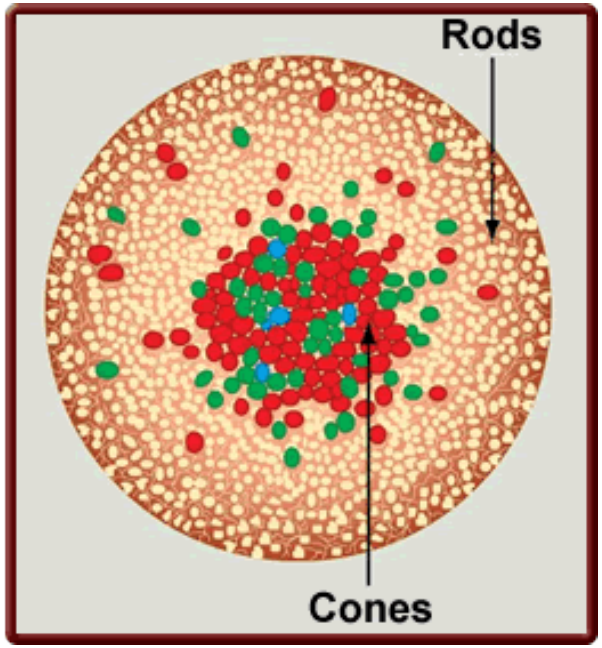
- This allows the lens to **focus** on objects at **varying distances**



The Eye – Retina

- The **retina** is a **screen** at the **back of the eye**
- This screen is made up of millions of light-sensitive cells called **rods** and **cones**
- Cones are located in the **central region** of the eye known as the **fovea**, which is the most light-sensitive area of the retina
- Rods are located around the cones



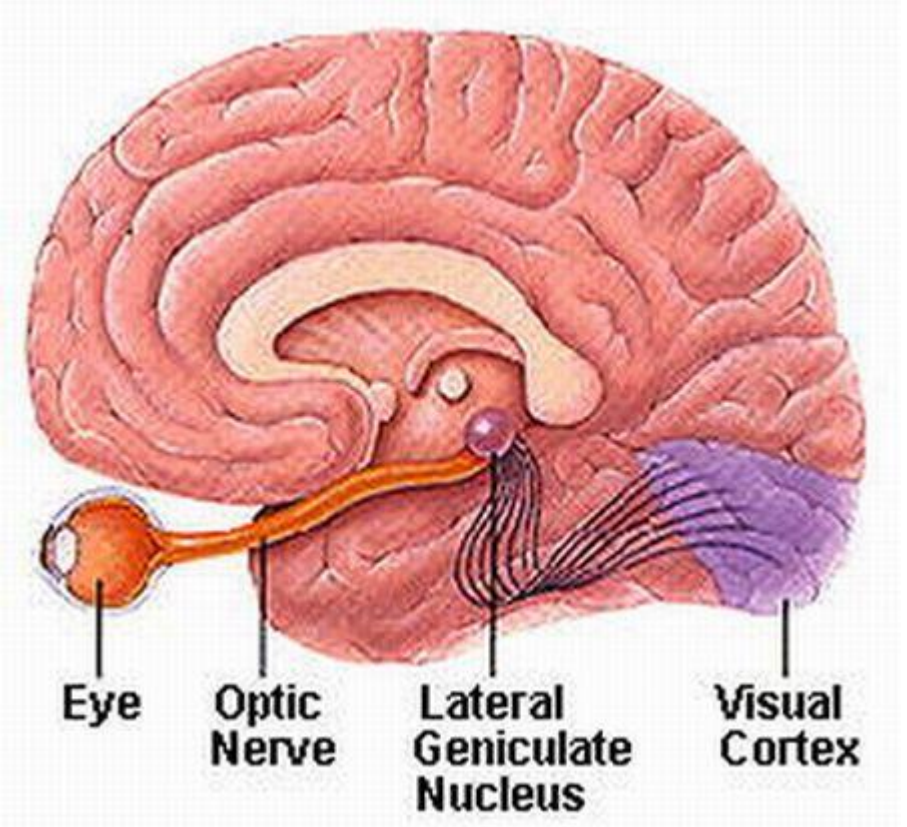


The Eye – Blind Spot

- Rods and cones **convert light rays into electrical impulses**
- These impulses are sent to the brain via the **optic nerve**
- The optic nerve is connected to the back of the eye – there are no rods or cones at this point
- This means that light rays focused on this point will not be seen – a **"blind spot"**

X **O**

Close your left eye and focus on the X. Very slowly, move your head toward the image and back again. Somewhere between five and twenty inches away the O will seem to disappear. That's your blind spot, your lacuna.



The Eye – Cones

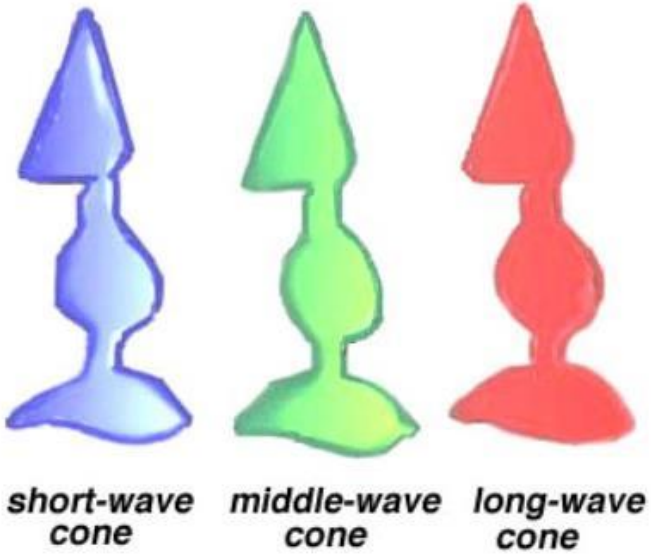
- Cones are sensitive to:

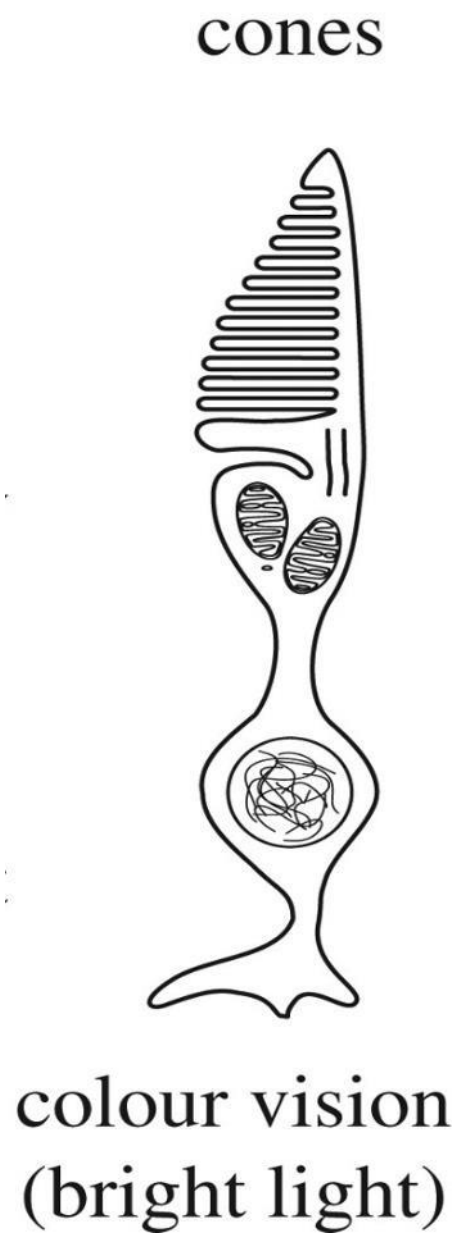
  1. Colour

  2. Small/fine details

  3. Distant objects

- They are most effective in **daylight** and are used when **looking directly** at an object





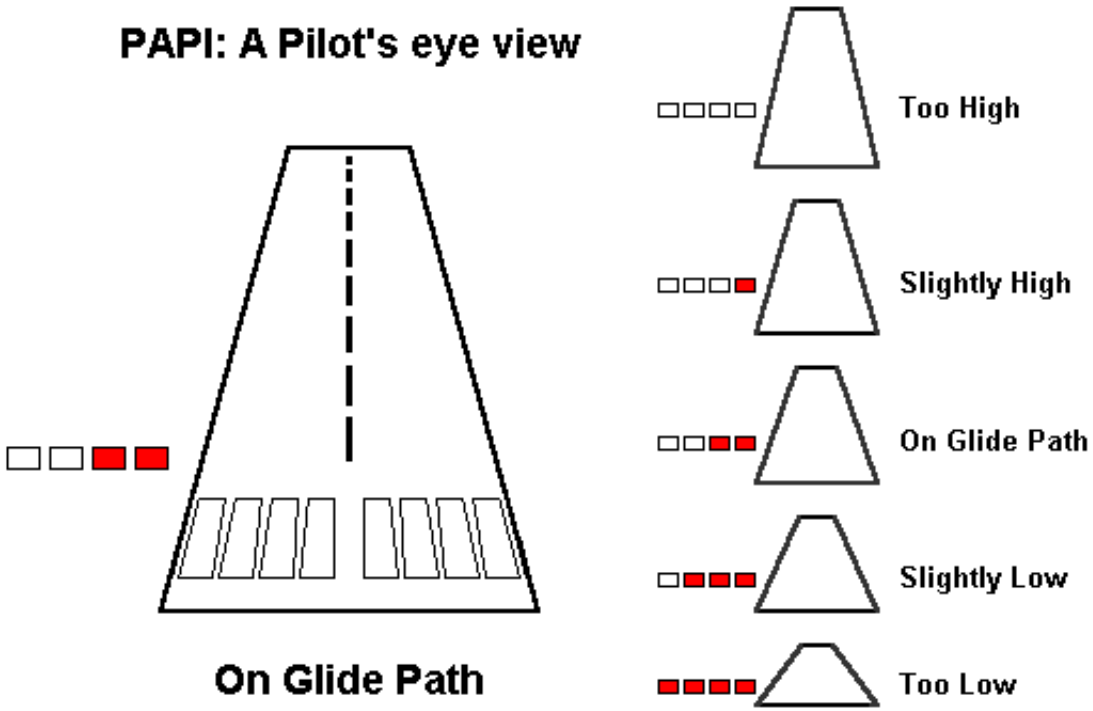
The Eye – Cones

- Cones are what give us **colour vision**

- This is important for pilots when:

1. Receiving light signals from the tower

2. Following a PAPI or T-VASIS approach guidance system



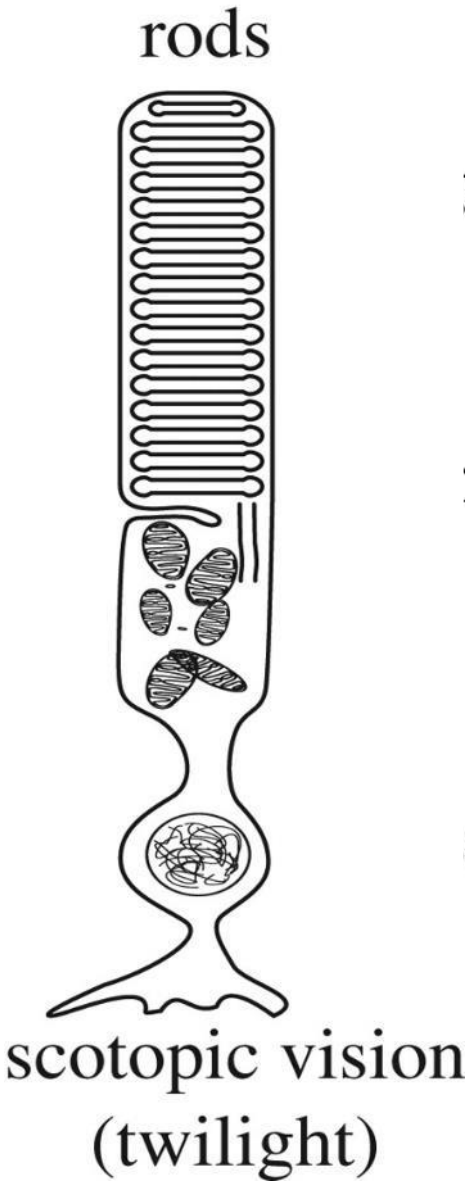
The Eye – Rods

- Rods are sensitive to **movement only**
- They are largely responsible for our:

  1. Peripheral vision

  2. Night vision

- Therefore, at night, it is better to **look slightly "off-centre"** from an object to focus on it more effectively



The Eye – Rods

- Although rods are used for night vision, they take time to “warm up”
- This is because a chemical called **rhodopsin** must be pumped into the rods which is extremely sensitive to light
- Full dark adaptation can take **30 to 40 minutes**
- Unfortunately, this process can be undone in an instant by a bright flash of light
- Even if the flash is momentary, another **30 minutes** is required for **dark re-adaptation**

The Eye – Rods

- Pilots flying at night should also try to avoid exposure to glare during the time before flight

- **Prolonged exposure to glare** such as snow or beach sand can reduce night vision by 30% – 50% for periods of up to **one week**

- Pilots flying at night should:

1. Dim cabin/cockpit lights and avoid looking at landing/strobe lights

2. Use red filters on lights/torches if required

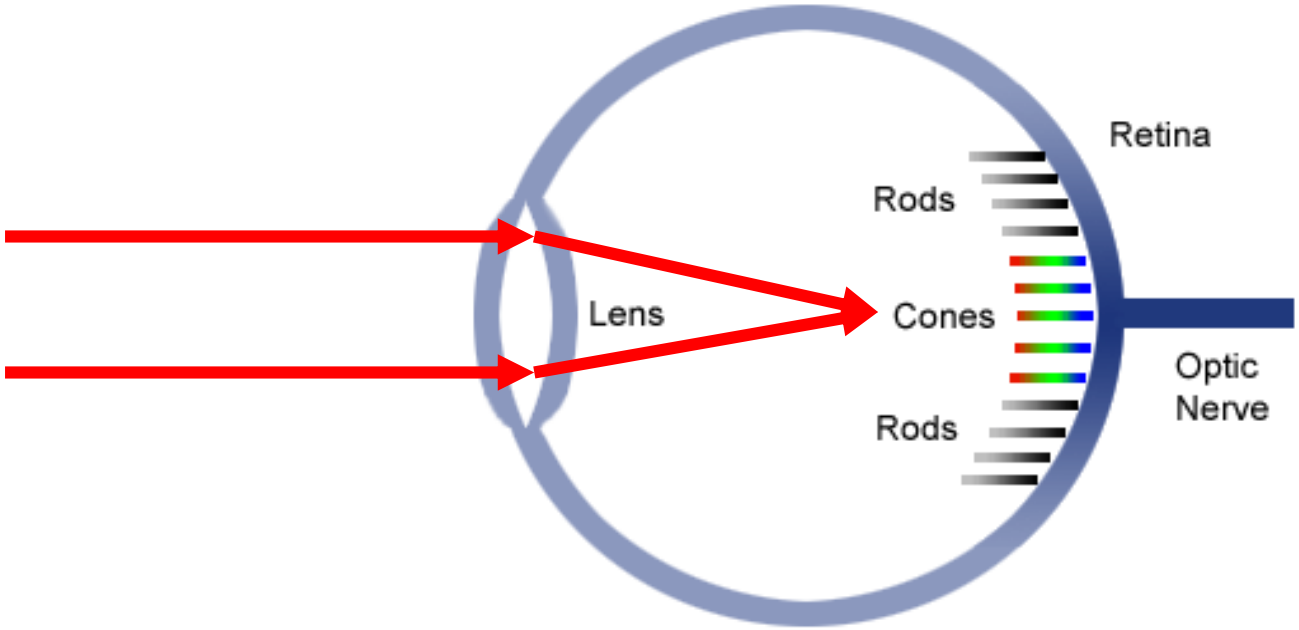
3. Avoid smoking – this will reduce your night vision at any altitude!

EYE PROBLEMS

Eye Problems

Myopia

- Short Sightedness
- Rays of light focus in front of the eye's retina

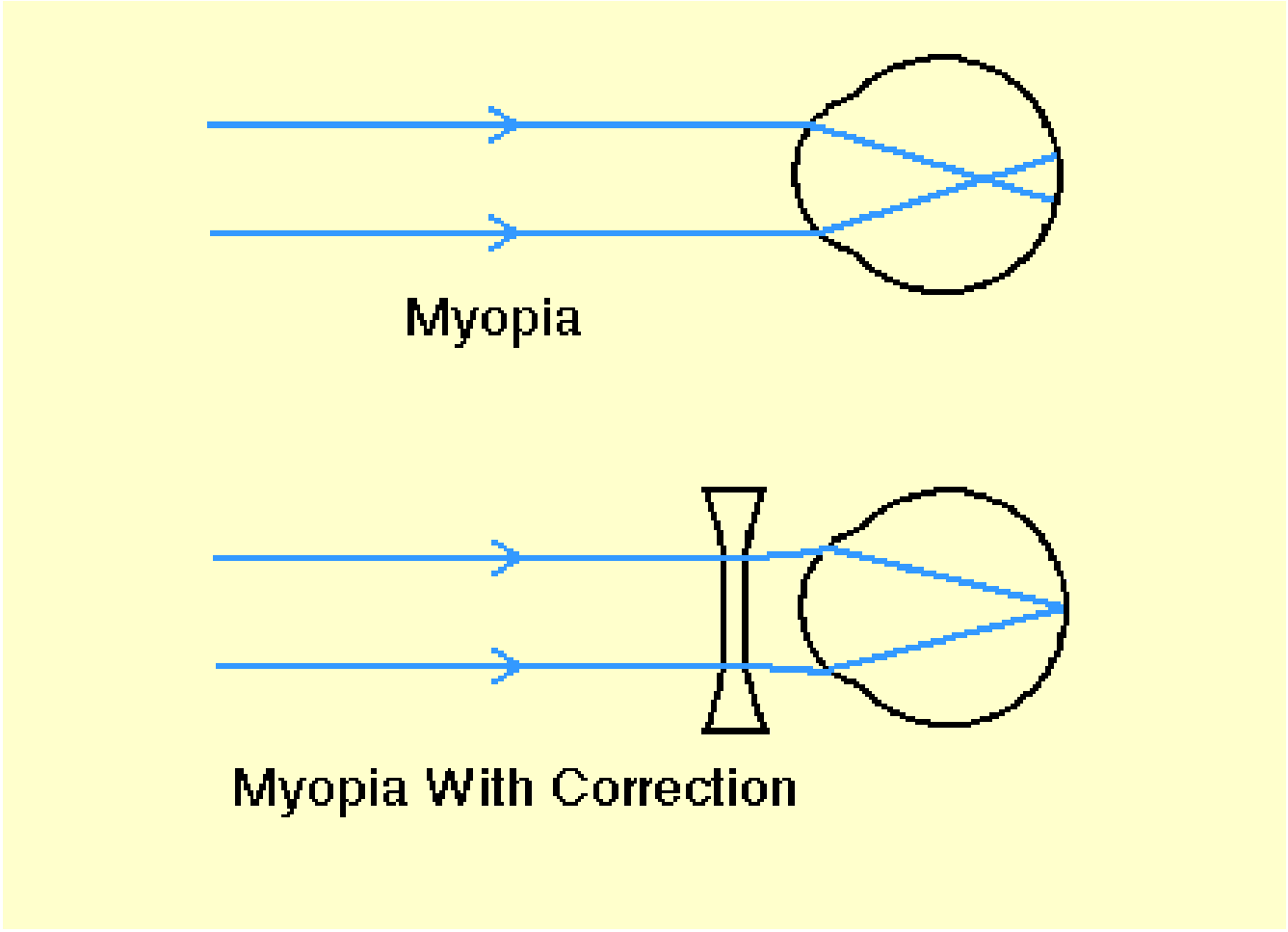


- Only near objects are seen clearly

Eye Problems

Myopia

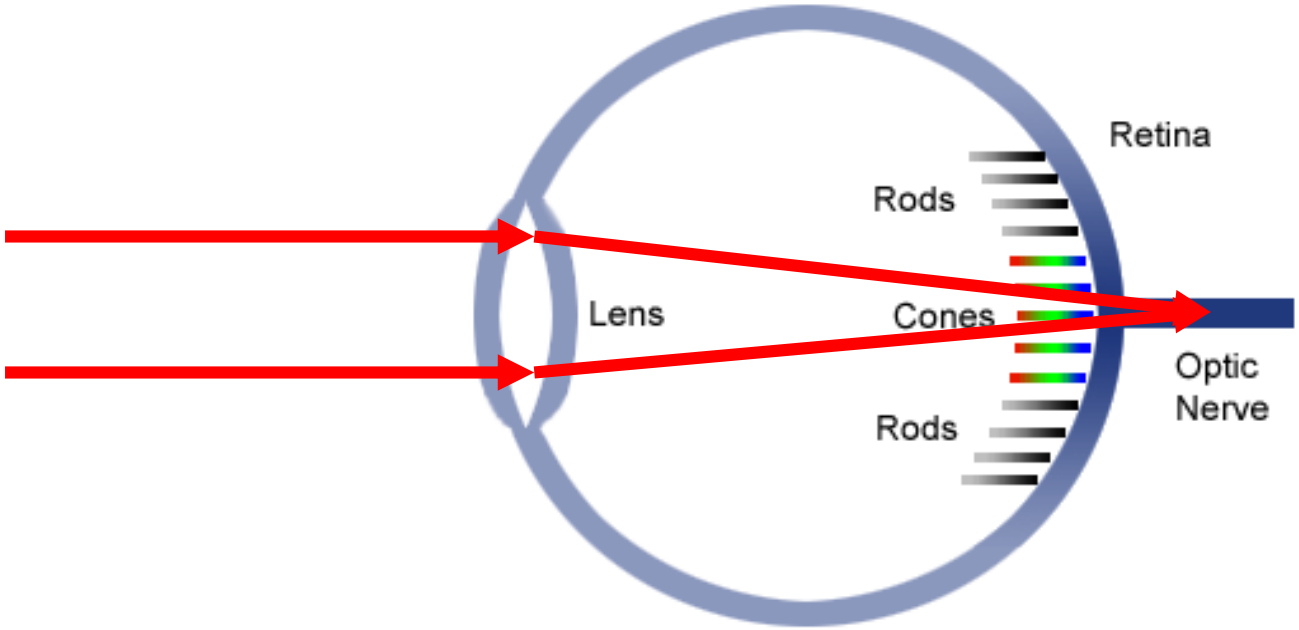
- Condition can be corrected using a **concave** lens



Eye Problems

Hyperopia

- Long Sightedness – also known as Hypermetropia
- Rays of light focus beyond the retina

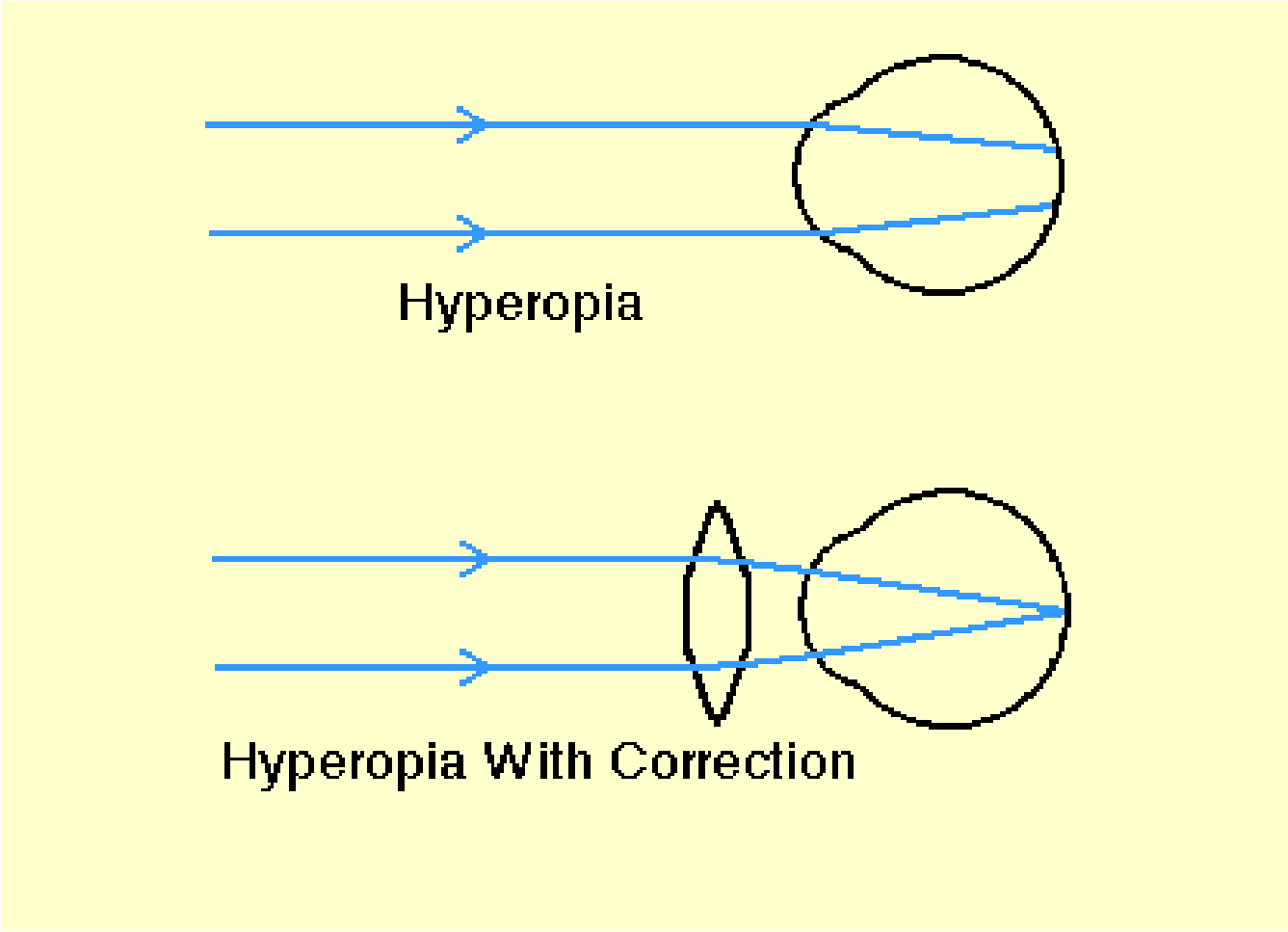


- Only distant objects are seen clearly

Eye Problems

Hyperopia

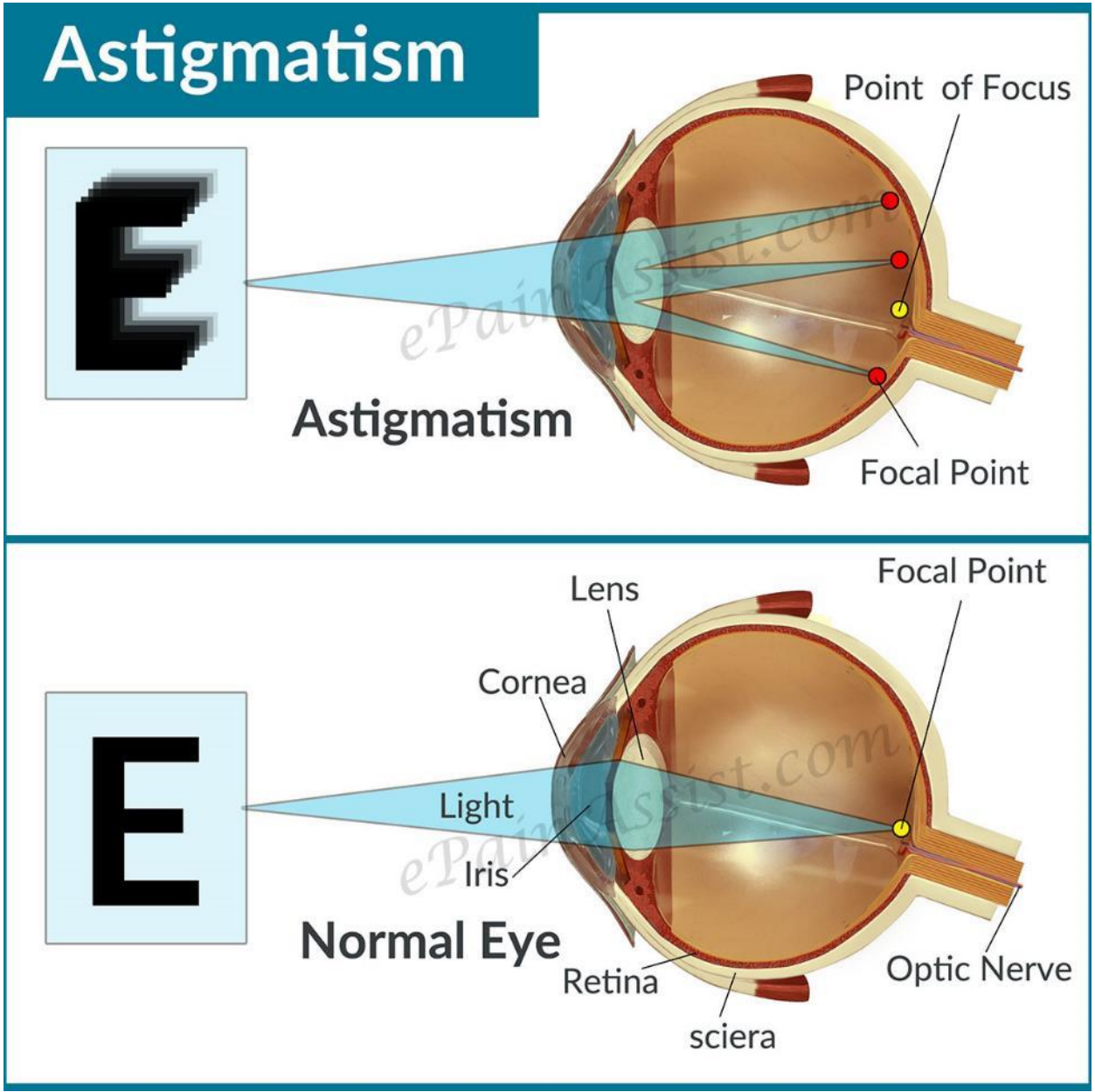
- Condition can be corrected using a **convex** lens



Eye Problems

Astigmatism

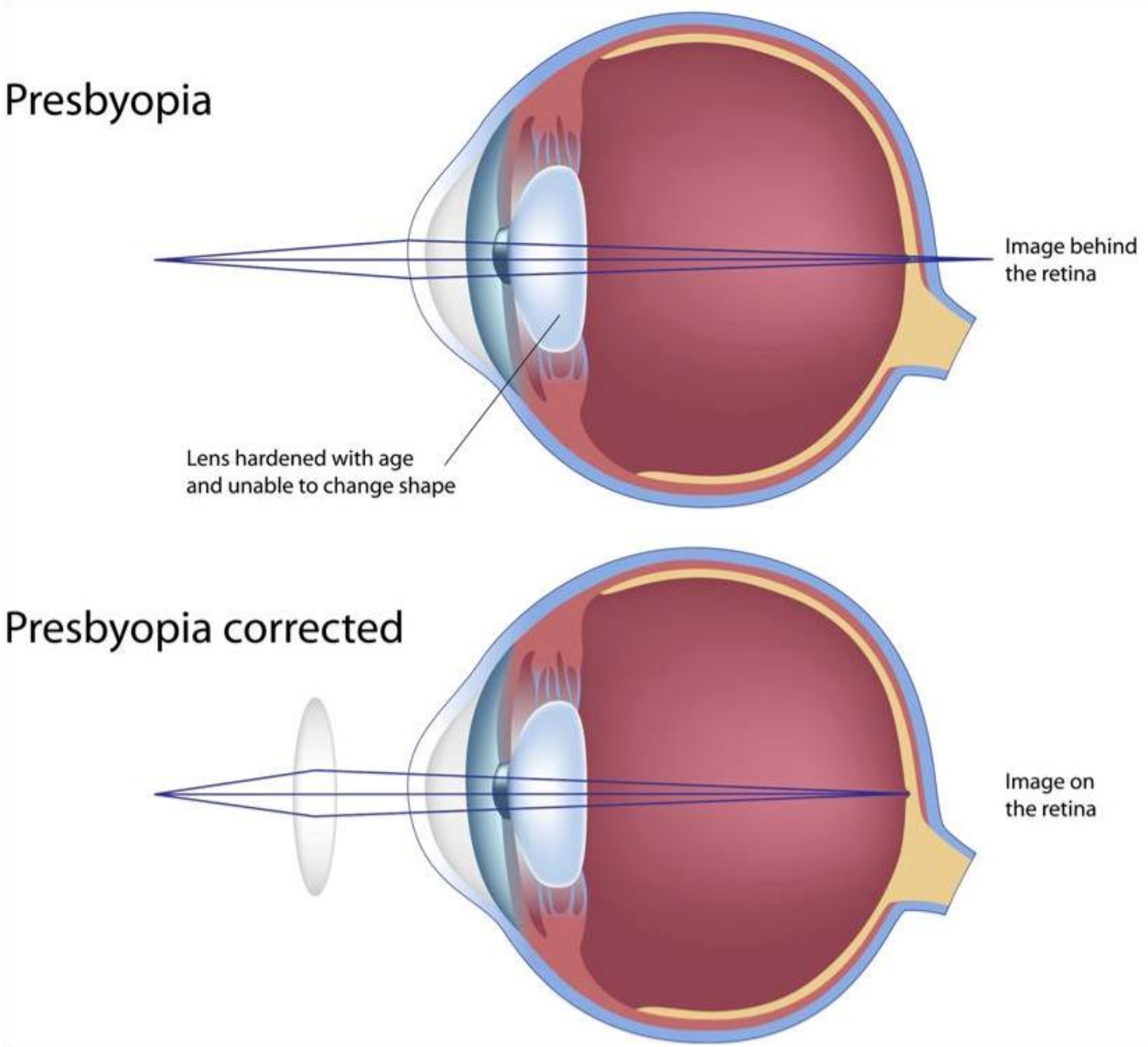
- The cornea (clear window at the front of the eye) is unevenly curved
- Rays of light will converge unequally



Eye Problems

Presbyopia

- The characteristics of the lens change and **long sightedness** occurs
- **A natural consequence of ageing** – this is why most people use glasses as they grow old



Eye Problems
Empty Field Myopia

Eye Problems

Empty Field Myopia

Eye Problems

Empty Field Myopia

- The tendency of the eye to take up its resting focus when there is **nothing for it to focus on**
- For example, this may occur when staring out at an **empty sky**, or when it is dark
- The distance is usually about **1-2 metres**
- This means that we can fail to see an aircraft until it gets very close
- Avoid this by **looking at the ground or wingtips from time to time** to refocus

Eye Problems

Motion Parallax Illusions:

- Is an Illusion based on apparent movements of objects at varying distances
- Objects viewed from a distance while a body is under motion appear to move more slowly to the pilot
- Objects viewed from a closer distance while a body is under motion appear to move much faster in comparison, &
- Therefore the we can say that objects when viewed by the pilot, travelling at great speed are “Apparently Closer”

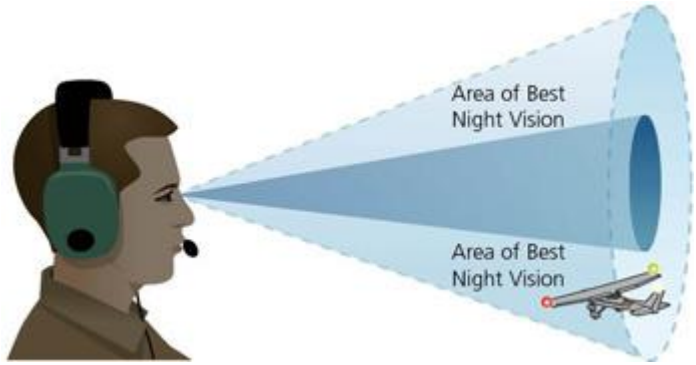
Eye Problems

Day blind spots:

- No photosensitive cells located at the point where the optic nerve and retina converge
- Binocular vision compensates

Night blind spots

- As the rods are absent from the fovea then vision is only available in the peripheral and in black and white
- Deliberate use of peripheral vision essential at night



Eye Problems

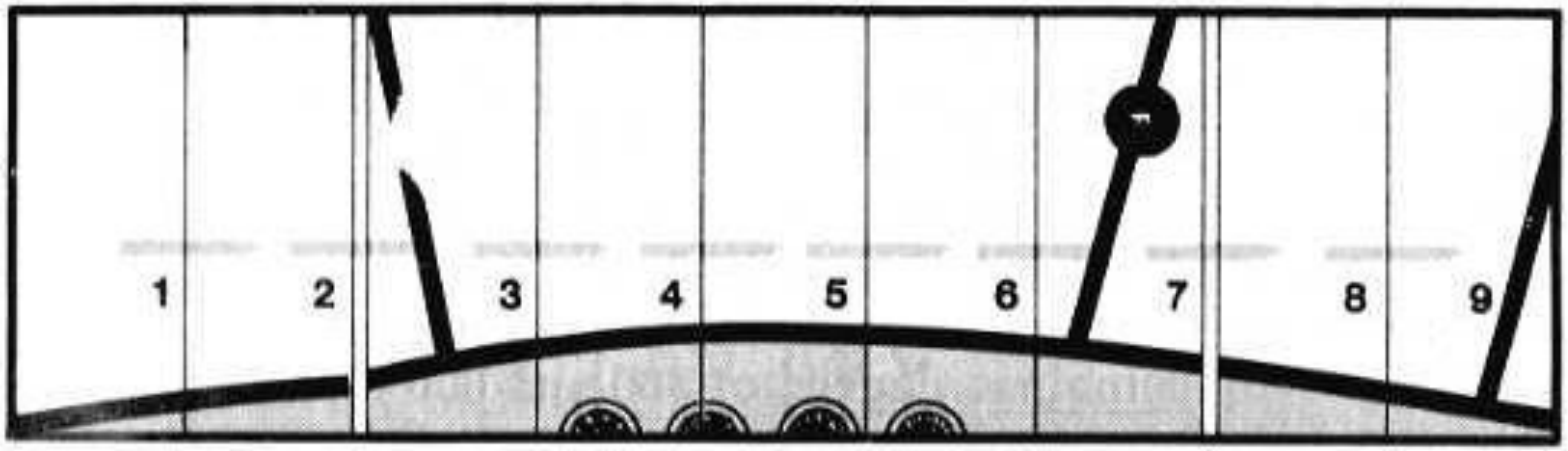
Glare:

- Is the difficulty in sight that arises from bright light
- It causes a reduction in Pupil size
- It can be remedied by good quality Sunglasses which are not polarised
- 15% luminance with a neutral gray lens is best for aircrew

VISUAL SCANNING TECHNIQUES

Visual Scanning Techniques

- The central (foveal) region of the retina provides the best vision during daylight
- Images are concentrated on this region by looking directly at them – therefore, **a continuous scan is ineffective** as the eye does not have time to fixate on any one particular image
- The recommended method is to use the **saccade-fixation cycle (or saccade/rest)**
- This is a series of short, regularly spaced eye movement of about 10°-20°



- Each movement of the eye takes about **one third of a second** before pausing again to focus on the new frame

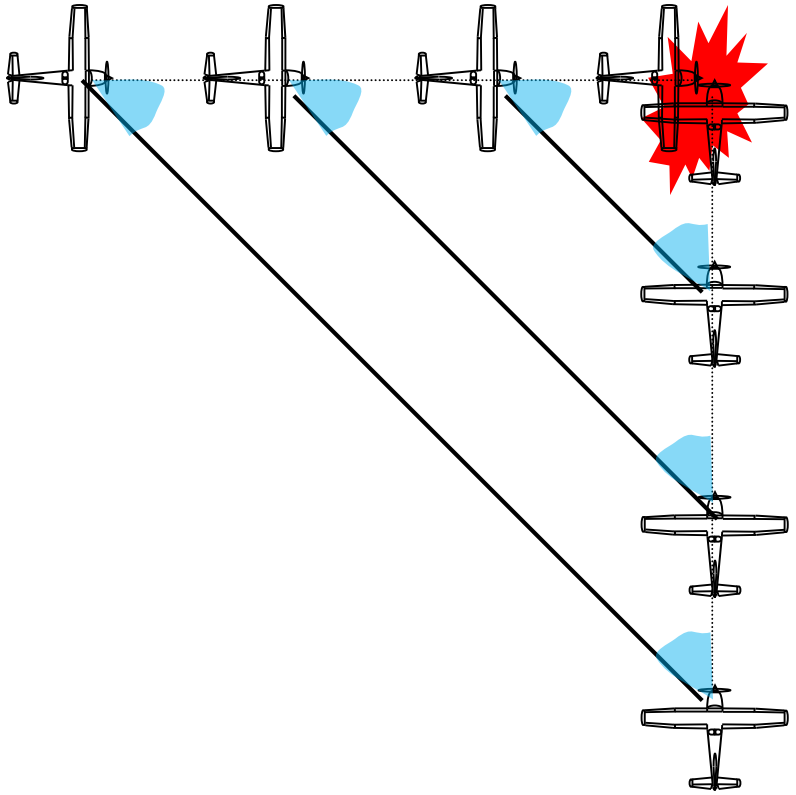
Visual Scanning Techniques

- Once traffic has been sighted, we then need to decide if it is a collision risk

- The easiest way to tell you are on a collision course is:

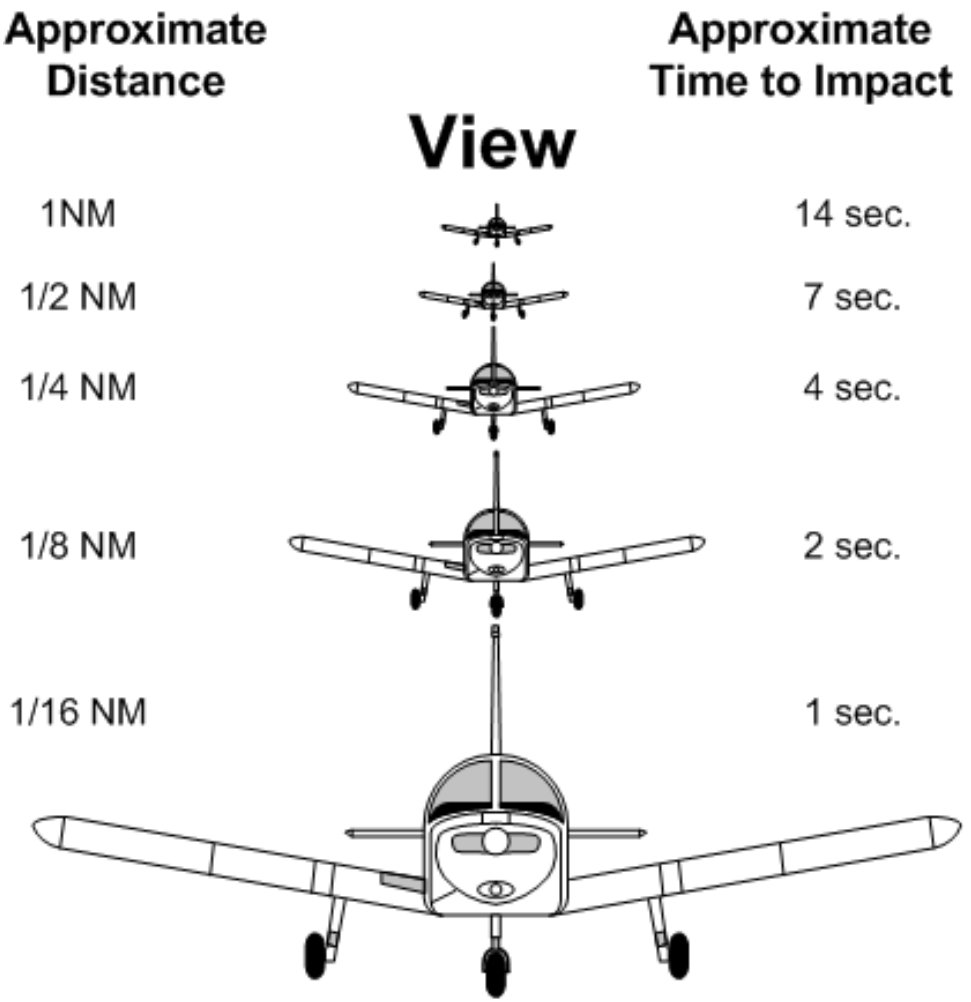
1. You are converging with another aircraft

2. That aircraft remains in the same position in your windscreen and grows larger



Visual Scanning Techniques

- A healthy eye will be able to see a dot 1mm in diameter at a distance of 3.6m
- Therefore, an aircraft with a fuselage approximately 1m wide would not be seen until it is within 2nm
- If both aircraft are travelling at 120KIAS, the closing speed is 4nm/minute
- **Therefore, from the moment the conflicting traffic enters your view, you have 30 seconds to avoid a collision!**



Measurements are approixmate, based on Transport Canada's *Human Factors for Aviation--Basic Handbook*, P. 79.

VISUAL ILLUSIONS

Visual Illusions

- To correctly sense the body's orientation **(equilibrium),** information is obtained from 3 sources

- The three primary systems involved in maintaining body equilibrium include:

1. The visual system – the dominant force

*i.e. The pilot can **see** the horizon*

2. The vestibular system – part of the inner ear that mediates balance

*i.e. The pilot's **semicircular canals***

3. The proprioceptive system – nerves of the muscles, skin etc.

*i.e. The pilot can **feel** their feet on the pedals (postural cues)*

- Although sight dominant, input from all systems is necessary for an accurate picture

Visual Illusions

- As we have already seen, the body relies on the visual, vestibular and proprioceptive systems for **body orientation**

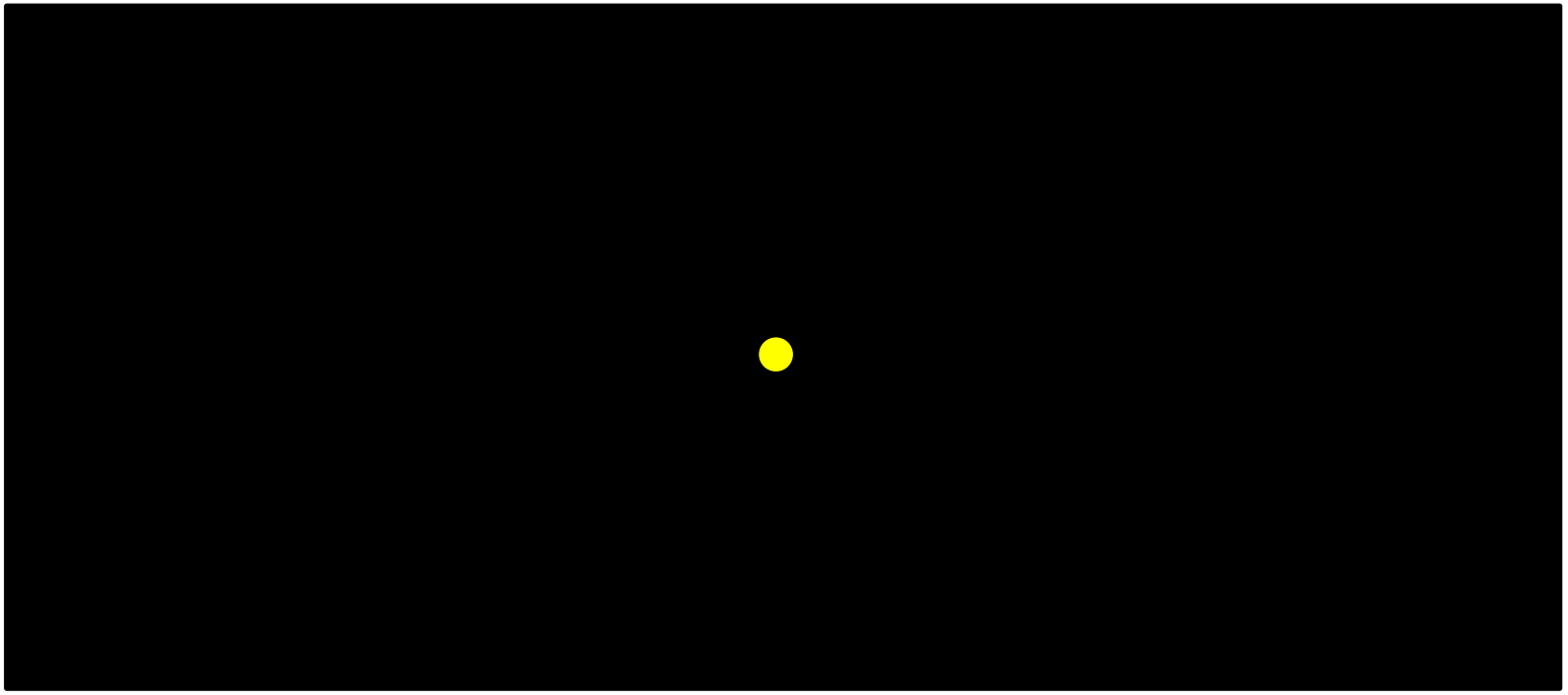
- If the brain receives different signals from these systems, **disorientation** can occur

- This can lead to various in-flight **illusions**

Visual Illusions

Autokinetic Illusion

- The apparent movement of a fixed light when the eye is fixed on it



- This can cause confusion with night flying, as stationary features can be mistaken for moving aircraft

- To avoid this, it is best to look at lights with peripheral vision rather than direct gaze

Visual Illusions

Environmental Perspective

- Normally, we would think that something indistinct must be far away and that something clearly defined is closer

- But atmospheric conditions and visibility are always changing, so this is not always true

- Pilots may underestimate distances on approach or from obstacles

- For example, in haze, you may be closer to the runway than you appear, resulting in hard landings if unprepared

Visual Illusions

False Horizons

- Low and sloping cloud bases and sloping mountain ranges can trick the pilot into adjusting to a false horizon

- This is particularly noticeable when drizzle or associated rain obscures the real horizon even further

- Trusting your flight instruments can overcome this

Visual Illusions

The Leans

- If an aeroplane enters a very gentle roll, the semi-circular canals of the ear may not register the variation

- However, it the pilot notices this on his/her instruments and abruptly levels the wings, the semi-circular canals will detect this sudden change

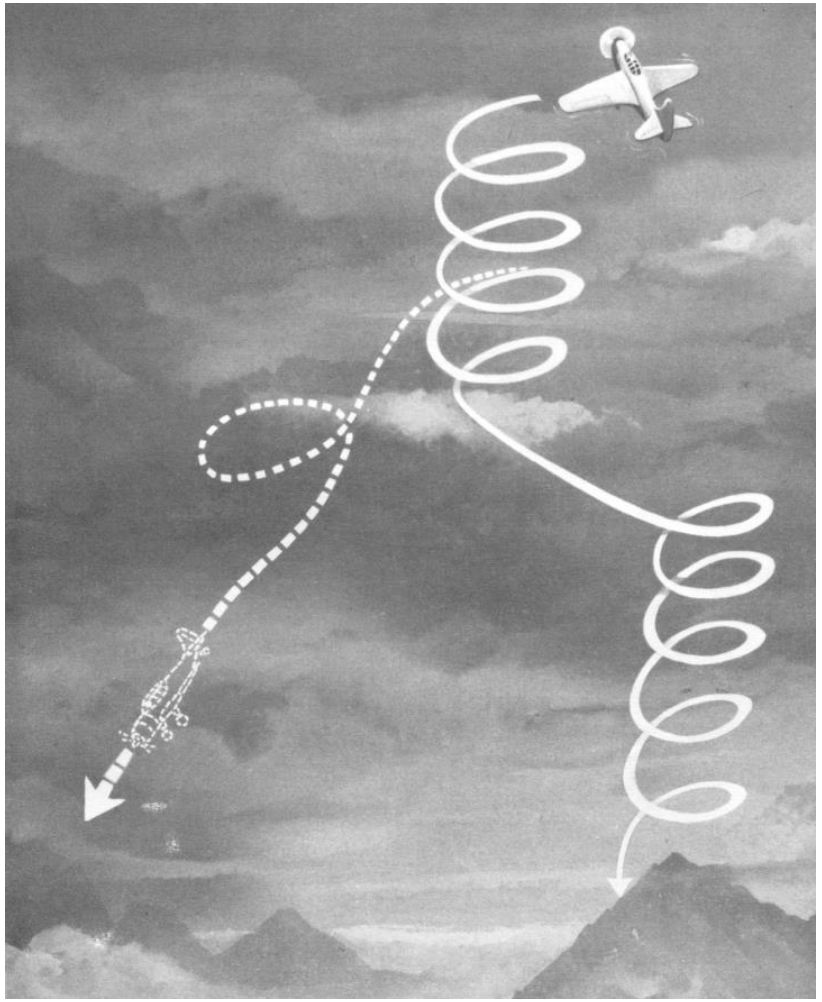
- The message sent to the brain will therefore be that the aircraft has rolled in the other direction, even though the wings are actually level

- This can occur in any of the three axes

Visual Illusions

Graveyard Spin

- A pilot who enters a spin to the left will initially have a sensation of spinning in the same direction
- However, if the spin continues, the pilot will have a sensation that the spin is progressively decreasing
- At this point, if he/she applies right rudder to stop the left spin, he will suddenly sense (falsely) a spin in the opposite direction (to the right)
- To counteract this, he will now apply left rudder, but will in fact re-enter the original left spin

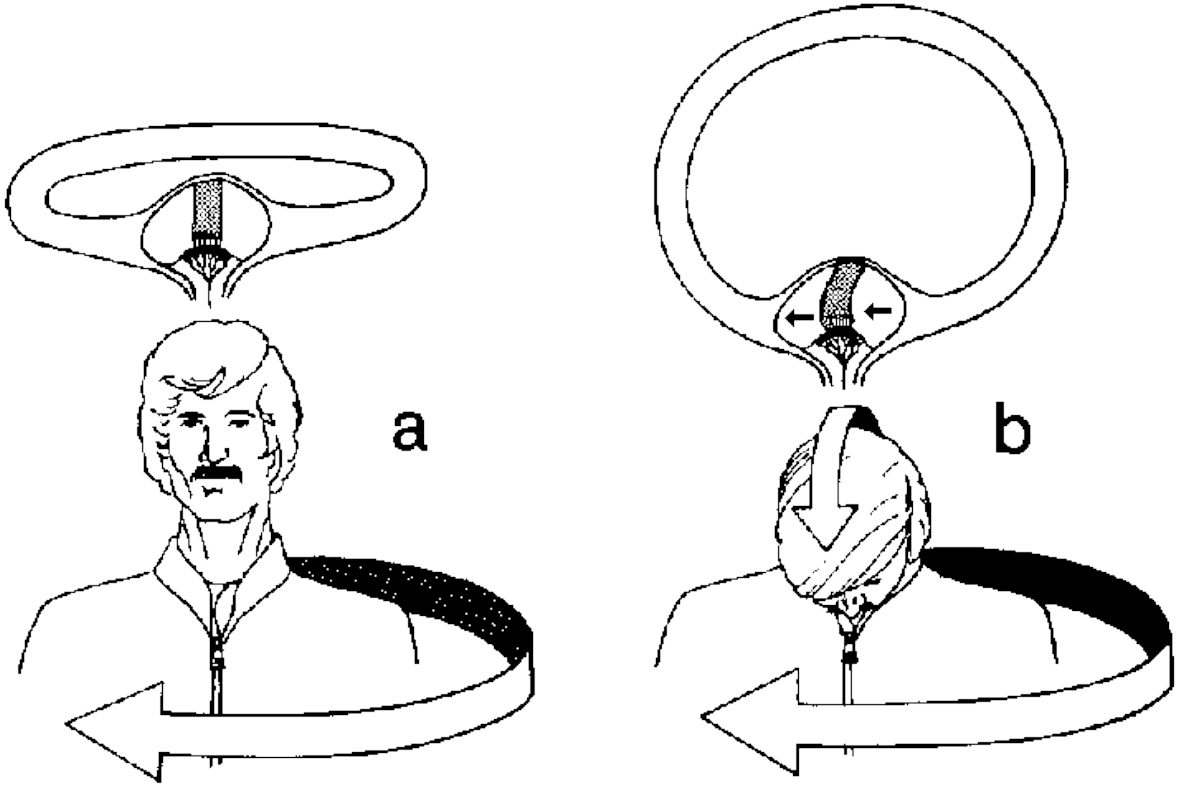


Visual Illusions

Coriolis Illusion

- If a turn is entered, and whilst still in that turn a pilot moves his head further e.g. to adjust HDG bug, that action generates further movement in the semi-circular canals

- Certain combinations produce a **tumbling sensation**, which is quite uncomfortable



Visual Illusions

Somatogravic Illusion

- Also known as **"Black Hole Effect"** – occurs during take-off or missed approach in poor visibility or at night
- If the pilot opens the throttle to full power and the aircraft accelerates, he/she may **mistake this acceleration for a climb – as there is no outside visual reference**
- Thinking it is too steep, the pilot pushes forward on the controls
- However, this only results in further acceleration, which the pilot incorrectly senses as further climb
- Again, he/she eases forward and the result is a descent into the ground
- To overcome this, we must **rely on the aircraft instruments when taking off at night or in poor conditions**

Visual Illusions

Flicker Vertigo

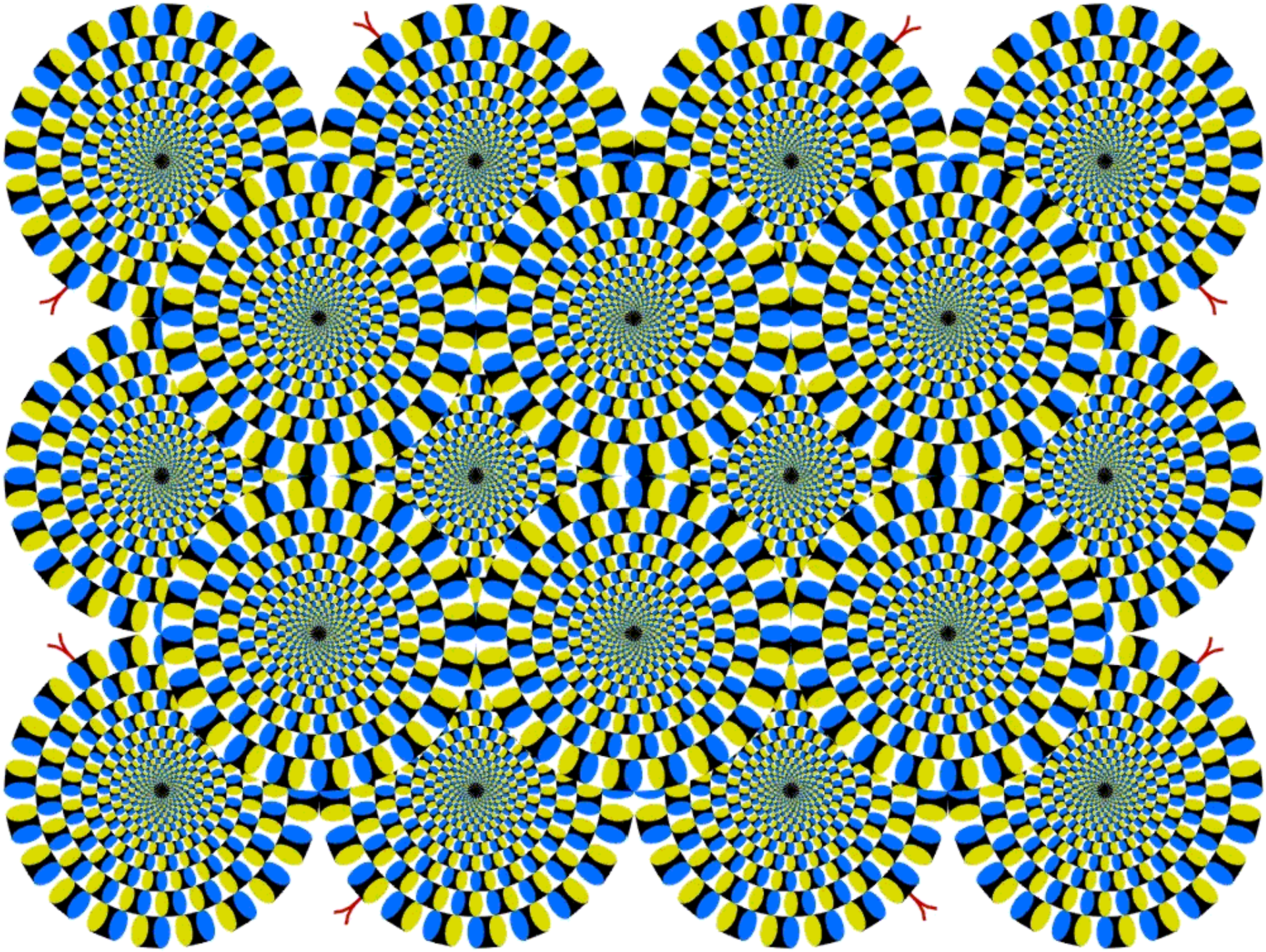
- Can occur in both helicopters and aeroplanes

- For example, as an aeroplane flies towards a low setting sun, the sun will appear to "flicker" or "strobe" between the rotating blades of the propeller, causing disorientation and nausea

- Vertigo can also occur whilst flying in cloud with strobe lights on – it is wise to turn off the strobes before flight inside cloud

Visual Illusions

https://www.youtube.com/watch?v=X35c-KwKZYA

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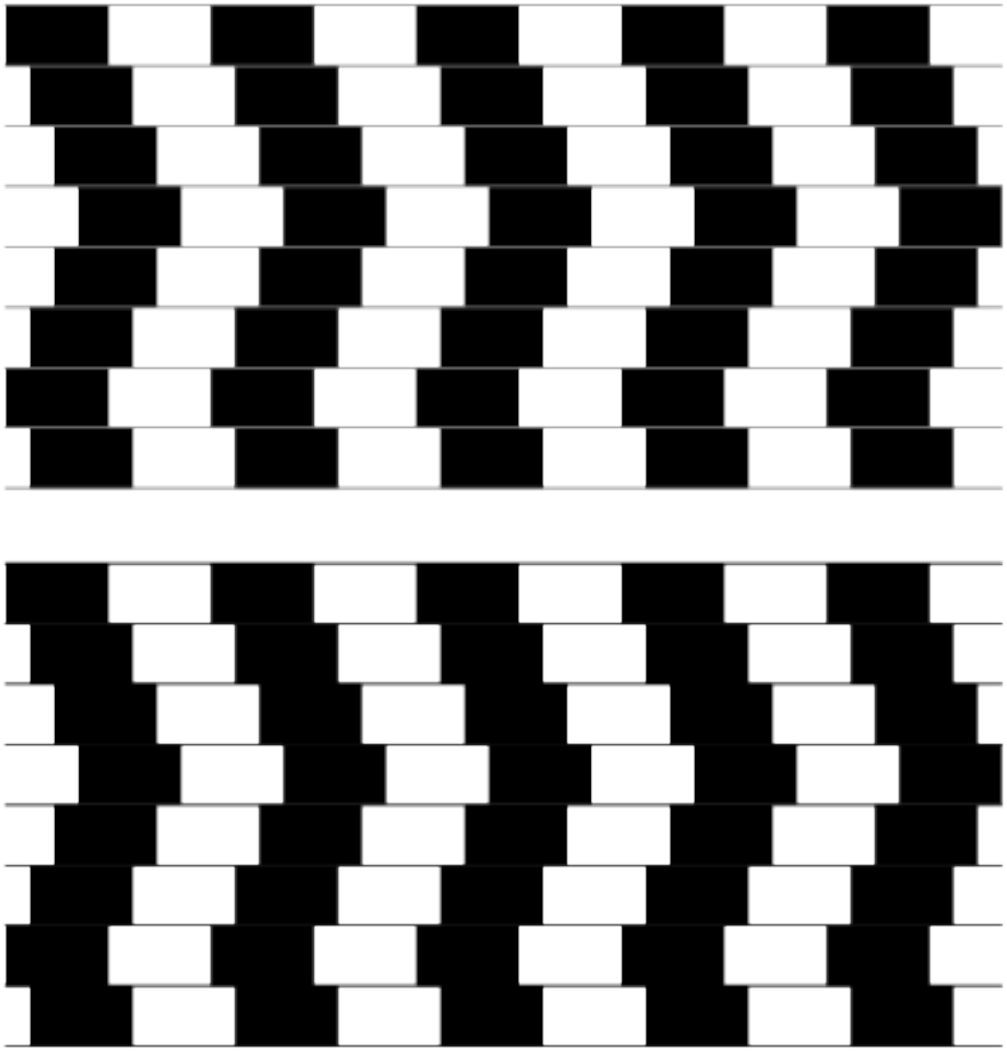
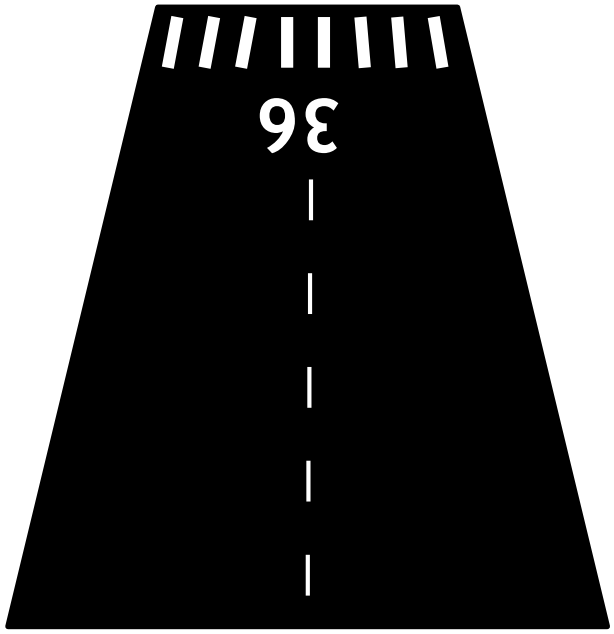


RUNWAY APPROACH ILLUSIONS

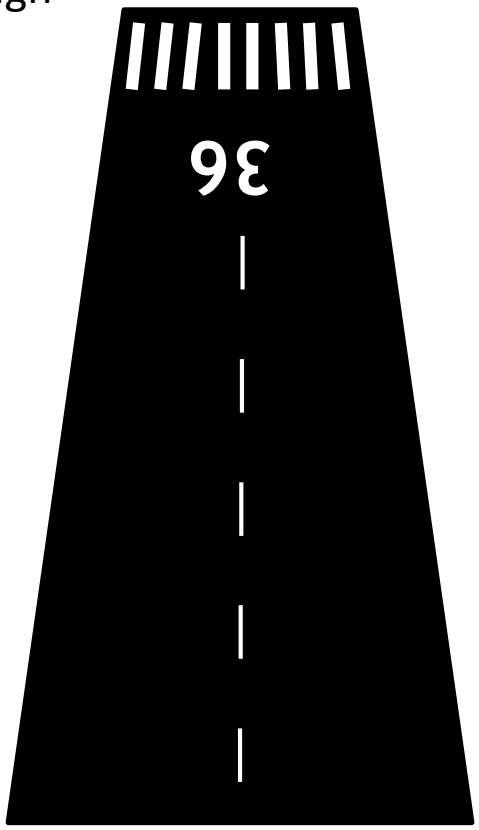
Landing Illusions – Runway Shape

If the runway is shorter and/or wider than what the pilot is used to, they may mistake this for an approach that is too low

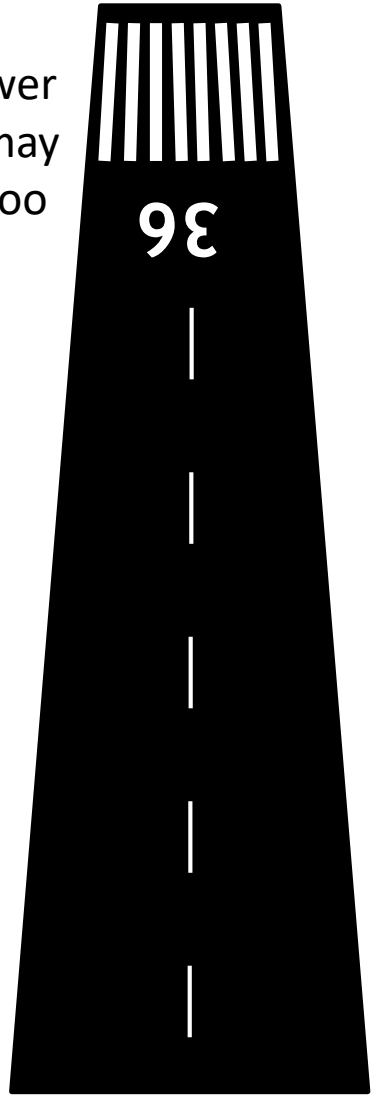


Approach too Low

If the runway is longer and/or narrower than what the pilot is used to, they may mistake this for an approach that is too high



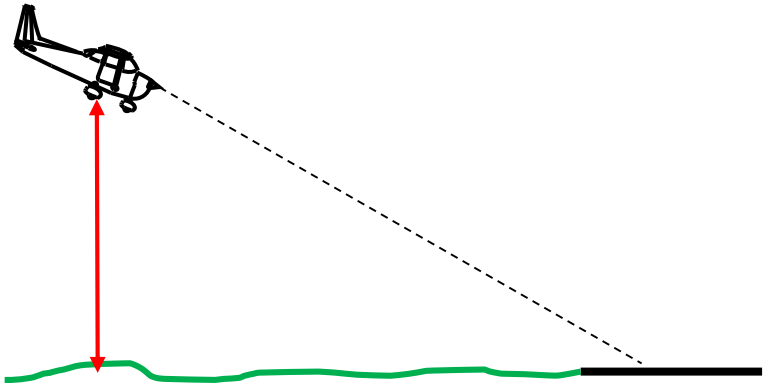
Correct Profile



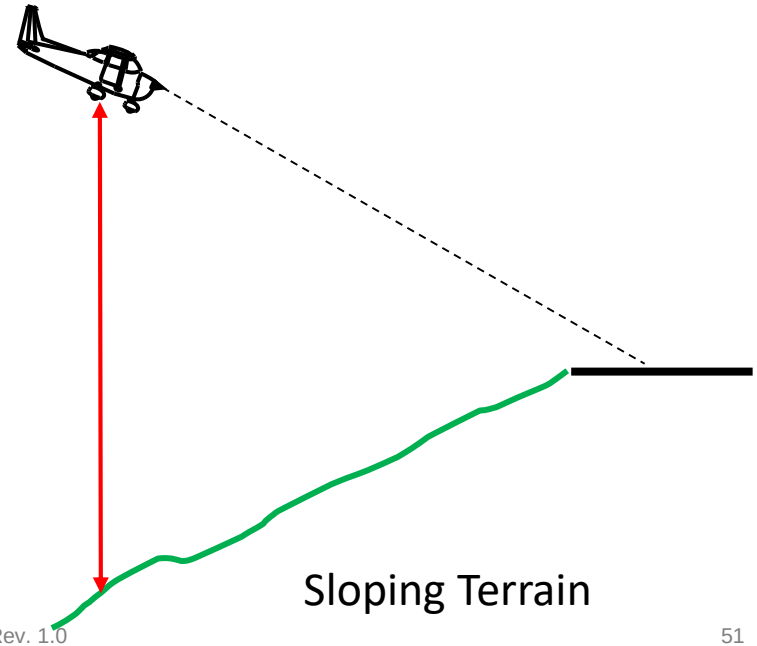
Approach too High

Landing Illusions – Sloping Terrain around Runway

When the terrain slopes up toward the landing threshold, the pilot feels as though they are high since they are further from the terrain the aircraft is tracking over

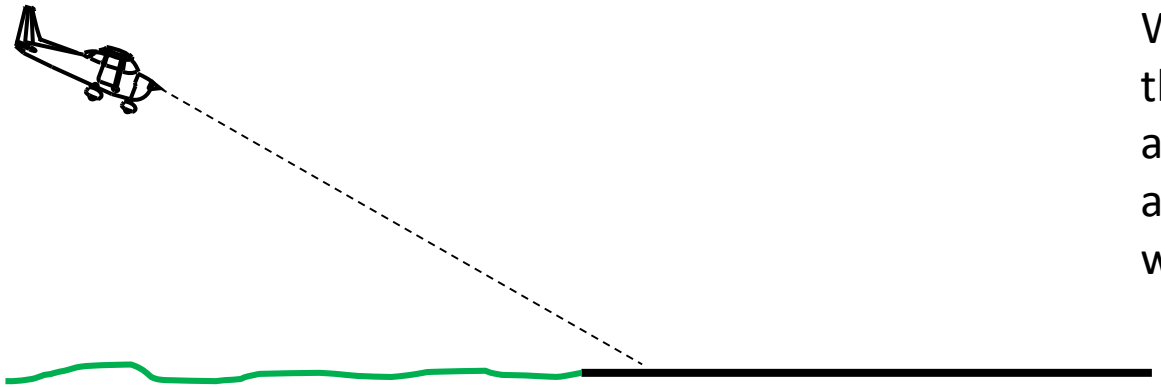


Flat Terrain

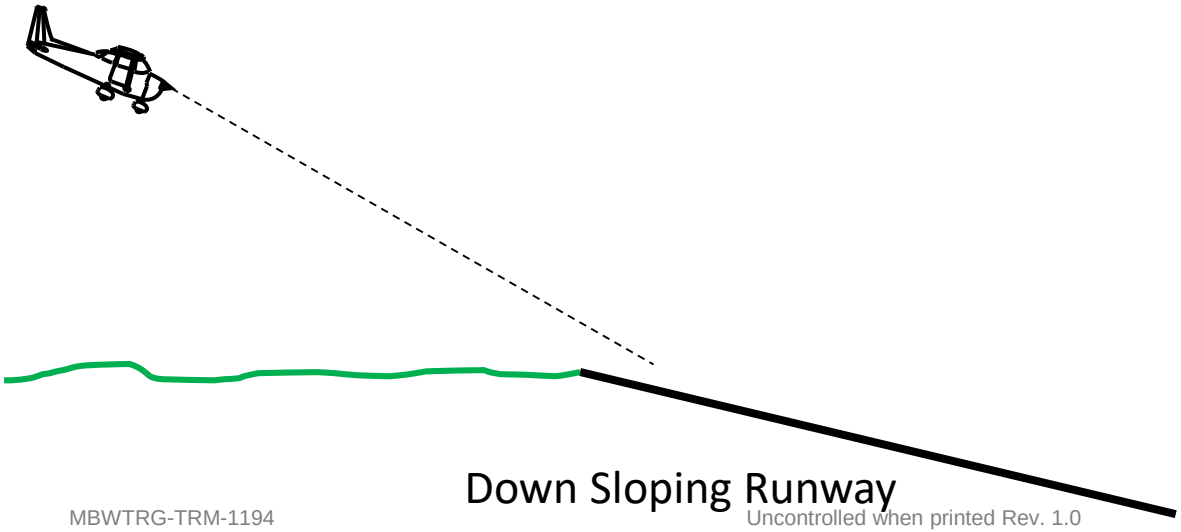


Sloping Terrain

Landing Illusions – Sloping Runway



Level Slope Runway

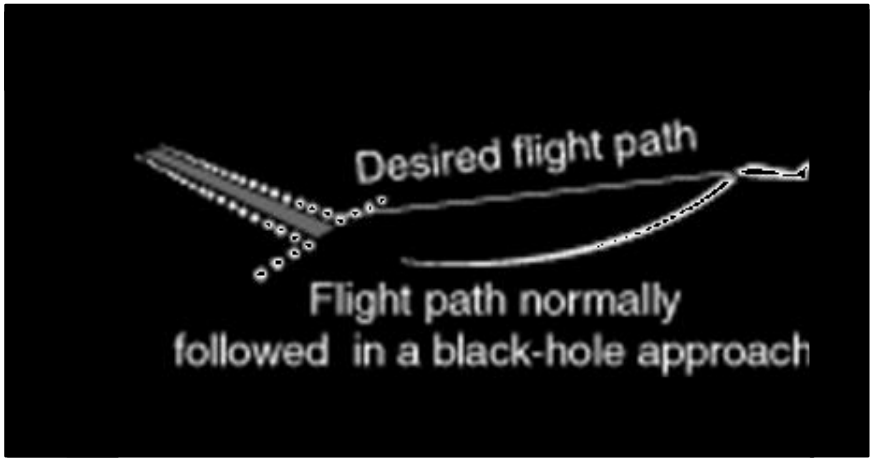


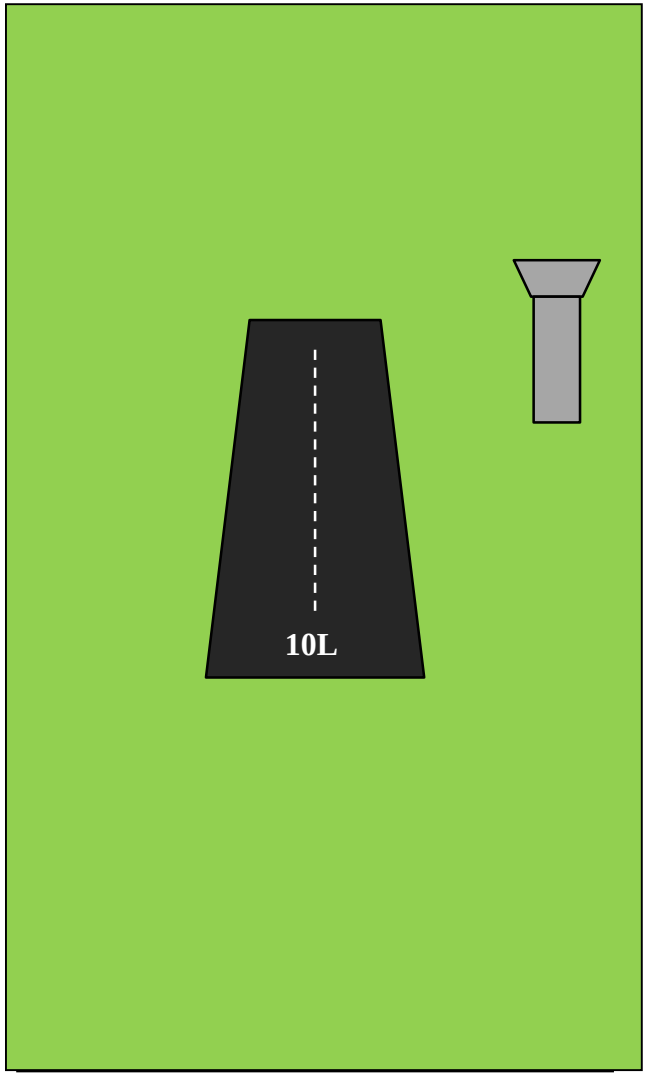
Down Sloping Runway

When the runway slopes down from the landing threshold, the pilot feels as though they are low since the approach path is closer to parallel with the runway

Landing Illusions – Black Approach

- During the day, we have visual cues to judge our descent profile
- However, this becomes more difficult at night
- The most common illusion is that we think we are **too high**
- This results in flying a **lower approach** and undershooting the runway





Runway Approach Illusions

Pilot feels they are high when...	Pilot feels they are low when...
Runway slopes up from the near threshold to the far threshold	Runway slopes down from the near threshold to the far threshold
Terrain slopes up to the near threshold	Terrain slopes down to the near threshold
Terrain slopes up from the far threshold	Terrain slopes down from the far threshold
Runway narrow or long	Runway wide or short
Approach over featureless terrain/water	
Approach is black	
Air is abnormally clear	
Runway lights brighter than usual	Runway lights dimmer than usual
Heavy rain on windscreen	Visibility poor
Risk: Low approach, undershoot and late flare	**Risk: High approach, overshoot and early flare**

OVERCOMING VISUAL ILLUSIONS

Overcoming Visual Illusions

How to overcome visual illusions:

- **The trick is to notice the Illusion and compensate accordingly**
- **Fly with visual reference**
- **Avoid staring at lights whether fixed or moving**
- **Scan slowly with pauses**
- **If in doubt on landing, go-around**
- **Allow eyes to adapt to the light conditions, and also**
- **Avoid fatigue**