

## **Q2: Explain Visual Representation in VR. [10]**

### **1. Stereoscopic Vision**

Stereoscopic vision creates a 3D effect by presenting two slightly offset images, one for each eye. This mimics how human eyes perceive depth naturally, making objects appear closer or farther. The brain combines these images to enhance depth perception. This is a fundamental technique used in VR to simulate a realistic environment.

### **2. Field of View (FOV)**

Field of View determines how much of the virtual world the user can see at once, replicating peripheral vision. A wider FOV (100-130 degrees) enhances immersion by making visuals feel more natural. Narrow FOV can feel restrictive and disrupt the sense of presence. VR systems aim to match human vision as closely as possible for realism.

### **3. Frame Rate and Refresh Rate**

Frame rate (FPS) determines how many frames are displayed per second, ensuring smooth motion. Refresh rate (Hz) is how often the display updates per second, with 90 Hz or higher being ideal. Low frame rates or refresh rates cause lag, stuttering, and motion sickness. Smooth visuals are critical for maintaining immersion and comfort.

### **4. Resolution and Pixel Density**

Resolution determines the clarity of visuals by increasing the number of pixels displayed. Higher resolutions reduce the "screen-door effect" where individual pixels are visible. Pixel density (PPI) ensures details are sharp and text is legible. Together, they make the virtual world appear more lifelike and immersive.

### **5. Depth Cues for Realism**

Depth cues include binocular cues like stereopsis and monocular cues like size, shading, and motion parallax. These cues help users perceive the spatial relationship between objects. Lighting, texture gradients, and shadows enhance depth realism. Accurate depth perception makes the environment more natural and engaging.

### **6. Tracking and Head Movement**

Head-tracking systems use sensors like gyroscopes and accelerometers to detect user movement. The visuals update instantly in real-time, aligning with the user's perspective. This creates a seamless connection between head motion and visual changes. Accurate tracking improves immersion and prevents disorientation.

## **7. Lighting and Shading**

Lighting and shading simulate how light interacts with surfaces to create shadows, reflections, and highlights. Techniques like global illumination ensure realistic light behavior across objects. Proper shading enhances material realism, such as glass, water, or metal surfaces. Realistic lighting makes virtual environments visually compelling.

## **8. Motion Blur and Anti-Aliasing**

Motion blur smoothens fast-moving visuals to prevent unnatural jagged motion. Anti-aliasing reduces jagged edges ("jaggies") on objects, enhancing smoothness and realism. Both techniques improve visual quality by refining how objects look during movement. These optimizations maintain immersion without distracting artifacts.

## **9. Visual Latency**

Latency refers to the delay between user actions and system responses, disrupting immersion. Low latency (below 20 milliseconds) is essential to ensure visuals feel natural and in sync. High latency causes a visual disconnect and motion sickness. Optimized VR systems prioritize real-time rendering to minimize latency.

## **10. Realism and Art Style**

Realism aims for lifelike visuals, often used in simulations or training programs for accuracy. Stylized art provides creative, abstract environments while reducing hardware demands. Both approaches enhance the VR experience depending on the application's goals. Visual coherence ensures users remain immersed in the intended world.