ARVR CT-2 ANSWER KEY

Question-1

(a) *Vanishing point A [6 4 8 2] and B [6 4 16 2], centre of projection at zc = -2, onto z = 0 plane:*

$A(3, 2, 4)$ and $B(3, 2, 8)$ $\left(\frac{-1}{(-2)} = \frac{1}{2} \text{ in matrix}\right)$

$P' = M \cdot P$ perspective projection matrix

$$P' = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 1/2 & 1 \end{bmatrix} \begin{bmatrix} 3 & 3 \\ 2 & 2 \\ 4 & 8 \\ 1 & 1 \end{bmatrix} = \begin{bmatrix} 1 & 3/5 \\ 2/3 & 2/5 \\ 0 & 0 \\ 1 & 1 \end{bmatrix}$$

projected points $A'(3\ 2\ 0\ 3)$

$B'(3\ 2\ 0\ 5)$

→ vanishing point : $(0\ 0\ 0)$

(b) *Depth of polygon in painter's algorithm*

The basic idea is to sort the polygons based on their distance from the viewer and then render them from back to front. This way, closer objects will overwrite farther ones, creating the illusion of depth. To determine the depth of a polygon in the Painter's algorithm, you need to calculate the distance of each polygon from the viewer or camera position.

(c) *What is a control point?*

A control point in the context of Bézier curves is a point that influences the shape of the curve. The number of control points depends on the degree of the Bézier curve.

(d) *What is ambient light?*

It is the combination of light reflections from various surfaces to produce a uniform illumination. It is nothing but background light.

Question-2

(a) *3D rotations – X then Y and Y then X rotations are same*:

The given statement is *false*. Let angle of rotation be θ.

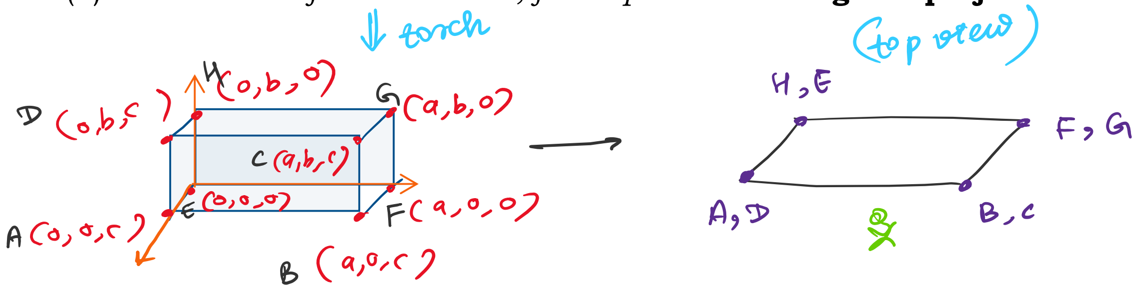
Transformation matrices R_x & R_y

$$R_x = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & \cos\theta & -\sin\theta & 0 \\ 0 & \sin\theta & \cos\theta & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \qquad R_y = \begin{bmatrix} \cos\theta & 0 & \sin\theta & 0 \\ 0 & 1 & 0 & 0 \\ -\sin\theta & 0 & \cos\theta & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

on multiplication $\underbrace{R_y \cdot R_x}_{\text{X then Y}} \neq \underbrace{R_x \cdot R_y}_{\text{Y then X}}$

As transformation matrices differ, they are not equivalent.

(b) *Coordinates of wooden table, find top view* – **orthogonal projection**.



(while projection occurs AD BC FG HE merge onto a single location)

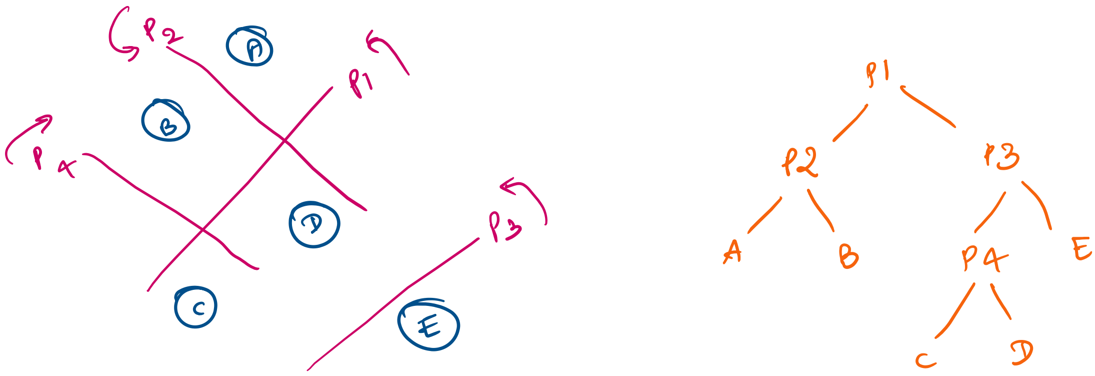
$$P' = M \cdot P$$

M: transformation matrix; P: point matrix

$$P' = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 0 & a & a & 0 & 0 & a & a & 0 \\ 0 & 0 & b & b & 0 & 0 & b & b \\ c & c & c & c & 0 & 0 & 0 & 0 \\ 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \end{bmatrix}$$

$$P' = \begin{bmatrix} 0 & a & a & a & 0 & a & a & 0 \\ 0 & 0 & b & b & 0 & 0 & b & b \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \end{bmatrix} \Rightarrow$$ (final orthogonal projected points)

(c) *BSP Tree*:



Question-3

(a) *Tracker signal is lost* due to various reasons like line-of-sight obstruction, interference, power loss, environmental factors, mechanical failure, etc.
(b) *Need for user-specific calibration in sensing glove*: Hand-size and shape variation, finger lengths, comfort, accurate gesture recognition.
(c) *Accuracy*: It represents the difference between the object's actual 3D position and that reported by tracker measurements.
Jitter: It represents the change in tracker output when the tracked object is stationary.

1. Optical Trackers:
   - *Accuracy: Dependent on precise calibration, camera resolution, and marker quality.*
   - *Jitter:* Influences immersive experiences; reduced by optimizing algorithms and minimizing environmental interference.
2. Inertial Trackers:
   - *Accuracy:* Relies on accurate calibration and sensor fusion to mitigate drift and noise.
   - *Jitter:* Mitigated by advanced algorithms, but challenges persist in long-term accuracy due to cumulative errors.
3. Magnetic Trackers:
   - *Accuracy:* Calibration critical; influenced by magnetic interference.
   - *Jitter:* Arises from interference; minimized by filtering algorithms and addressing environmental factors.
4. Ultrasonic Trackers:
   - *Accuracy:* Depends on transducer placement, calibration, and tracking space geometry.
   - *Jitter:* Resultant from signal reflections and interference; reduced through optimization and signal processing.
5. Mechanical Trackers:
   - *Accuracy:* Relies on precision mechanical components and design considerations.
   - *Jitter:* Arises from friction, backlash, or wear; minimized with quality components and regular maintenance.

Question-4

(a) *Design considerations to be followed for developing good haptic feedback interfaces*:

User safety and comfort: While the user interacts with virtual objects, the forces he or she feels are real. These contact forces need to be large (in the simulation of rigid objects), but not large enough to harm the user. In this context a good design is also fail-safe, so that users are not subject to accidents in case of computer failure.

Portability and user comfort: The difficulty with force-feedback actuators is the need to provide sufficient force while keeping the feedback hardware light and unintrusive. If haptic interfaces are too heavy and bulky, then the user will get tired easily and will prefer a less cumbersome open-loop control. Heavy feedback structures can be gravity counterbalanced, but these further increases complexity and cost. Portability also relates to ease of use and installation at the simulation site.

Haptic feedback interfaces should be self-contained, without requiring special supporting construction, piping, or wiring.

(b) *What kind of haptic feedback can be obtained?*

a. *Joystick*: Force feedback - Force feedback goes beyond simple vibration and allows the joystick to exert resistance or force against the user's input, simulating the feel of real-world forces. For example, a force feedback joystick used in flight simulation might simulate the resistance of the controls in different flight conditions.
b. *Cyberforce*: Force feedback - Allow simulation of object weight & inertia.
c. *iFeel*: Tactile feedback – It is like a standard mouse. Addition of an electrical actuator that can vibrate the mouse outer shell.