27/10/19

Assignment-1

① Explain the principles of Computer Animation?

A: * **Principles of Computer Animation:**

→ To study various techniques and algorithms used in computer animation, it is used to first understand their relationship to the animation principles used in hand-drawn animation.

→ These principles are "squash & stretch, timing, secondary actions, slow in & slow out, arcs, follow through or overlapping actions, exaggerating, appeal, anticipation, staging and straight ahead versus pose to pose."

• **Simulating Physics:**

→ Squash & stretch, timing, secondary actions, slow in & slow out, and arcs establish the physical basis of objects in the scene.

→ A given object possesses some degree of rigidity and should appear to have some amount of mass.

→ This is reflected in the distortion "(squash & stretch)" of its shape during an action, especially a collision. The animation must support these notions consistently for a given object throughout the animation.

→ "Timing" has to do with how actions are spaced according to the weight, size and personality of an object or character and, in part with the physics of movement as well as the artistic aspects of the animation.

→ "secondary actions" support the main action, possibly supplying physically based reactions to an action that just occured.

→ "Slow in & Slow out" and "arcs" are concerned with how things move through space. Objects slow in & slow out of poses. When speaking of the actions involved, objects are said to ease in and ease out.

· Designing Aesthetic Actions:

→ Exaggeration, appeal and follow through/overlapping actions are principles that address the asthetic design of an action or action sequence.

→ Often the animator needs to "exaggerate" a motion so it cannot be missed or so it makes a point (Tex Avery is well known for this type of conventional animation).

→ To keep the audience's attention, the animator needs to make it enjoyable to "watch (appeal)."

→ In addition, actions should flow into one another "(follow through/overlapping action)" to make the entire shot appear to continually evolve instead of looking like disjointed movements.

→ Squash & stretch can be used to exaggerate motion and to create flowing action. Secondary actions & timing considerations also play a role in designing motion.

· Effective Presentation of Actions:

→ Anticipation and staging concern how an action is presented to the audience.

→ "Anticipation" dictates that an upcoming action is set up so that the audience knows it is coming.

→ "Staging" expands on this notion of presenting an action so that it is not missed by the audience.

→ Timing is also involved in effective presentation to the extent that an action has to be given the appropriate duration of the intended effect to reach the audience.

→ Secondary actions and exaggeration can also be used to create an effective presentation of an action..

• Production Technique:

→ straight ahead versus pose to pose concerns how a motion is created.

→ "straight ahead" refers to progressing from a starting point and developing the motion continually along the way.

→ Physically based animation could be considered a form of this. "Pose to Pose", the typical approach in conventional animation, refers to identifying key frames & then interpolating intermediate frames

② Explain about display pipeline (spaces, transformation from one-to other)?

A: * Display Pipeline:

→ The display pipeline refers to the transformation of object data from its original defined space through a series of spaces until its final mapping onto the screen.

→ The object data are transformed into different spaces in order to efficiently compute illumination, clip the data to the view volume, and perform the perspective transformation.

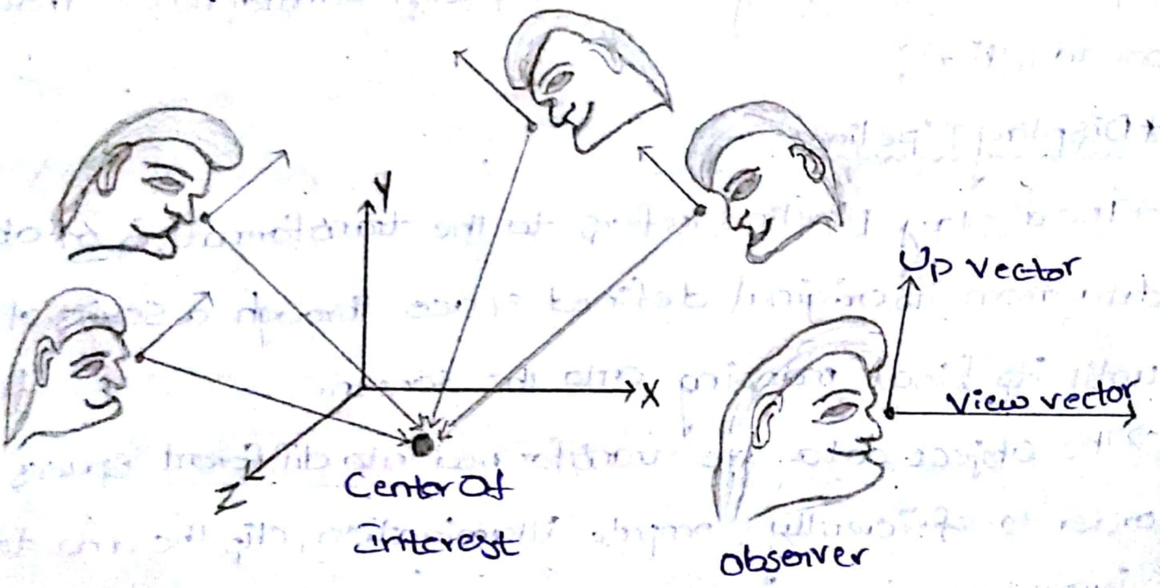
→ The space in which an object is originally defined is referred to as object space. The data in object space are usually centred around the origin and often are created to lie within some limited standard range such as -1 to +1.

→ The object, as defined by its data points, is transformed usually by a series of rotations, translations and scales into world space, in which objects are assembled to create the environment to be viewed.

→ The world space is the space in which light sources and the observers are placed. Here observer position is used synonymously and interchangebly with camera position & eye position.

→ The observer parameters include its position and its orientation, consisting of the view direction and up vector.

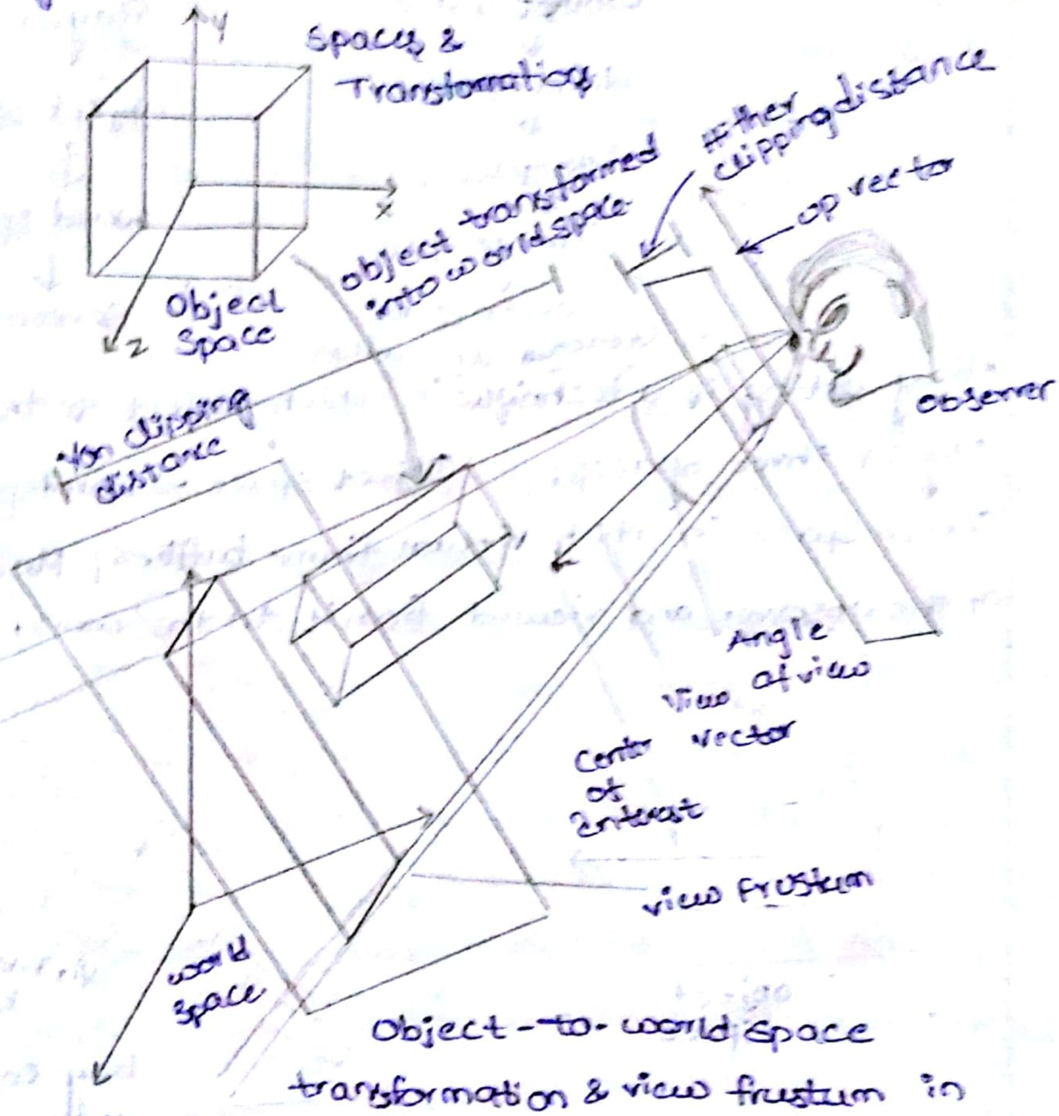
→ There are various ways to specify these orientation vectors. Sometimes the view direction in the vector from the observer or eye position (EYE), also known as the look-from point, to its center of interest also known as look-to point.



→ In addition to the observer position and orientation, the feild of view has to be specified, as it standard in the display piepline.

→ This includes an angle of view (or the equally useful half angle of view), hither clipping distance and yon clipping distance. Sometimes the terms near and far are used instead of hither and yon.

→ The visible area of world space is formed by the observer position, view direction, angle of view, hither clipping distance & yon clipping distance. These define the view frustum, the six-sided volume of world space containing data that need to be considered to display.



Object-to-world space transformation & view frustum in world space.

→ The perspective transformation transforms the object's data points from eye space to image space.

→ In any case, animation is typically produced by the following: a) modifying the position and orientation of objects in world space over time; b) modifying the shape of objects over time; c) modifying display attributes of objects over time; d) transformation the observer position & orientation in world space over time; e) or these combinations.

③ Write about the following: a) Ray casting and b) Production pattern?

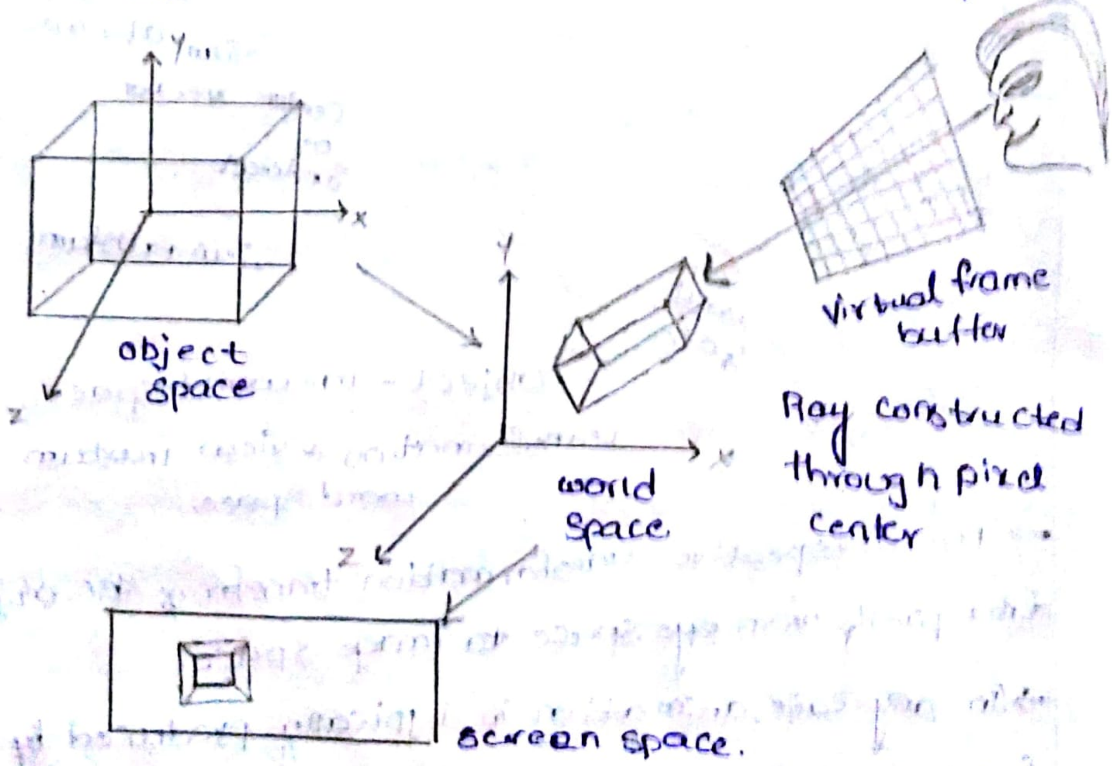
A:

a) Ray Casting:

In general, the animation pattern is followed according to:

General Animation	Raycasting
Object space	Object space
↓	↓
World space	World space
↓	↓
Eye space	Screen space
↓	
Image space	
↓	
Screen space.	

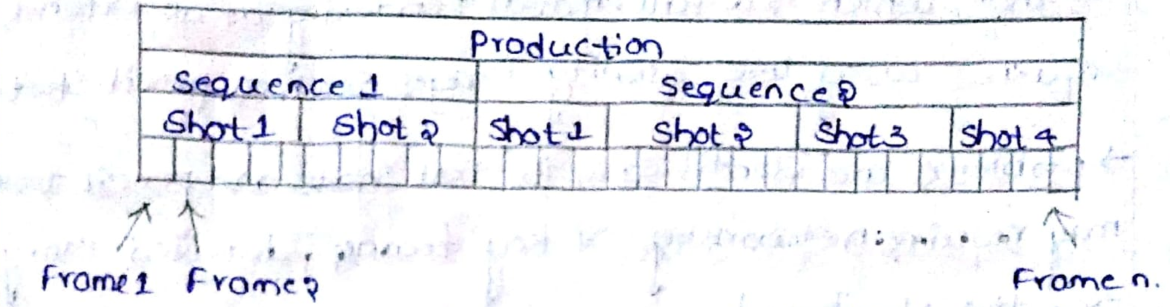
• Ray casting is a technique in which object is transformed only in three spaces: Object space → worldspace → Screen space in which virtual frame buffer is placed in front of the observer and viewed from it to the world space.



→ In this, technique, object is transformed from object space to world space, & now virtual frame buffer, the viewer can view object and is then the object now is directly transformed into screen space.

(b) Production Pattern:

→ The overall animation, the entire project is referred to as the "production". Typically, productions are broken into major parts referred to as "sequences." A sequence is broken down into one or more "shots". A shot is broken down into the individual "frames" of film. A frame is a single recorded image.



- Preliminary story - It is decided on, including a script.
- Storybord - It is developed that lays out the action scenes by sketching representative frames.
- Model Sheet - It is developed that consists of a no. of drawings for each figure in various poses and is used to ensure that each figure's appearence is conisestant as it is repeteadly drawn during the animation process.
- Exposure sheet - It records information for each frame such as sound track cues, camera moves & compositing elements.
- Route Sheet - It records the statistics and responsibility for each scene.
- Anamatic / Story Feel - It may be produced in which the storyboard frames are recorded, each for as long as the sequence it represents, thus creating a rough review of the timing.
- Detailed Story - It is worked out to identify the actions in more detail.
- key Frames - It is also known as extremes are then identified and produced by master animators to aid in confirmation of character development & image quality.

• In-betweening - Associate and assistant animators are responsible for producing the frames between the keys.

• Test Shots - A short sequences rendered in full color, are used to test the rendering and motions.

• Pencil test - To completely check the motion, pencil test may be shot, which is a full-motion rendering of an extended sequence using low-quality images such as pencil sketches.

→ problems are identified in the test shots and pencil tests may require networking of key frames, detailed story or even the storyboard.

• Inking - It refers to the process of transferring the penciled frames to cels.

• Opquaing - It is also called painting, is the application of color to these cels.

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④ Write about Homogeneous coordinates and basic transformations?

A: * Homogeneous Coordinates:

→ Computer graphics often uses homogeneous representation of points. This means that a three dimensional point is represented by a four-element vector.

→ The coordinates of the represented point are determined by dividing the fourth component into the first three

$$\left(\frac{x}{w}, \frac{y}{w}, \frac{z}{w}\right) = [x, y, z, w]$$

→ Typically, when transforming a point in world space, the fourth component will be one. This means a point in space has very simple homogeneous representation.

$$(x, y, z) = [x, y, z, 1]$$

* Basic Transformations:

• The transformations. rotate, translate and scale can be considered for basic transformations. These transformations and any combination of them are referred to as affine transformations.

$$\begin{bmatrix} x' \\ y' \\ z' \\ 1 \end{bmatrix} = \begin{bmatrix} a & b & c & d \\ e & f & g & h \\ i & j & k & m \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} x \\ y \\ z \\ 1 \end{bmatrix}$$

Translation
* ~~Rotation~~:

• The x, y and z translation values of the transformation are the first three values of the fourth column (d, h and m).

• The upper left 3x3 submatrix represents rotation and scaling. setting the upper left 3x3 submatrix to an identity transformation and specifying only translation produces as:

$$\begin{bmatrix} x+t_x \\ y+t_y \\ z+t_z \\ 1 \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & t_x \\ 0 & 1 & 0 & t_y \\ 0 & 0 & 1 & t_z \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} x \\ y \\ z \\ 1 \end{bmatrix}$$

* Scaling:

• A transformation consisting of only uniform scale is represented by the identity matrix with a scale factor, S replacing the first three elements along the diagnol (a, f, k).

• Non uniform scale allows for independent scale factors to be applied to the x, y & z-coordinates of a point & is formed by placing S_x, S_y & S_z along diagnol.

$$\begin{bmatrix} S_x \cdot x \\ S_y \cdot y \\ S_z \cdot z \\ 1 \end{bmatrix} = \begin{bmatrix} S_x & 0 & 0 & 0 \\ 0 & S_y & 0 & 0 \\ 0 & 0 & S_z & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} x \\ y \\ z \\ 1 \end{bmatrix}$$

• Uniform scale can also be represented by setting the lowest rightmost value to $1/s$. In homogeneous representation, the coordinates of the point is represented are determined by dividing the first three elements of vector by the fourth, thus scaling up the values by the scale factor s.

$$\begin{bmatrix} s \cdot x \\ s \cdot y \\ s \cdot z \\ 1 \end{bmatrix} = \begin{bmatrix} x \\ y \\ z \\ 1/s \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1/s \end{bmatrix} \begin{bmatrix} x \\ y \\ z \\ 1 \end{bmatrix}$$

* Rotation:

• values to represent rotation are set in the upper left 3x3 submatrix(a, b, c, e, f, g, i, j, k). Rotation matrices around the x-, y- & z- axis in a right-handed coordinate system.

$$\begin{bmatrix} x' \\ y' \\ z' \\ 1 \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & \cos\theta & -\sin\theta & 0 \\ 0 & \sin\theta & \cos\theta & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} x \\ y \\ z \\ 1 \end{bmatrix}$$ // Along x-axis / yz plane

$$\begin{bmatrix} x' \\ y' \\ z' \\ 1 \end{bmatrix} = \begin{bmatrix} \cos\theta & 0 & \sin\theta & 0 \\ 0 & 1 & 0 & 0 \\ -\sin\theta & 0 & \cos\theta & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} x \\ y \\ z \\ 1 \end{bmatrix}$$ // Along Y-axis / xz plane

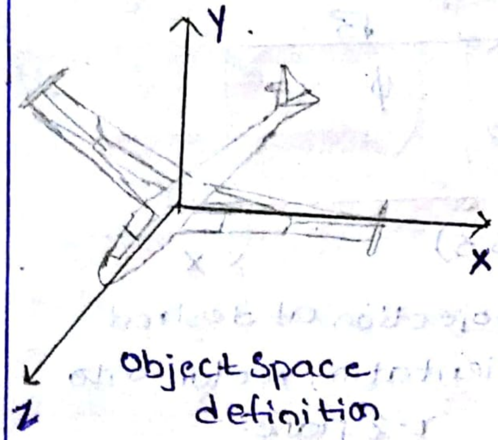
$$\begin{bmatrix} x' \\ y' \\ z' \\ 1 \end{bmatrix} = \begin{bmatrix} \cos\theta & -\sin\theta & 0 & 0 \\ \sin\theta & \cos\theta & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} x \\ y \\ z \\ 1 \end{bmatrix}$$ // Along z-axis / xy plane.

• Combinations of rotations and translations are usually referred to as rigid transformations because the spatial extent of the object does not change; only its position and orientation in space are changed.

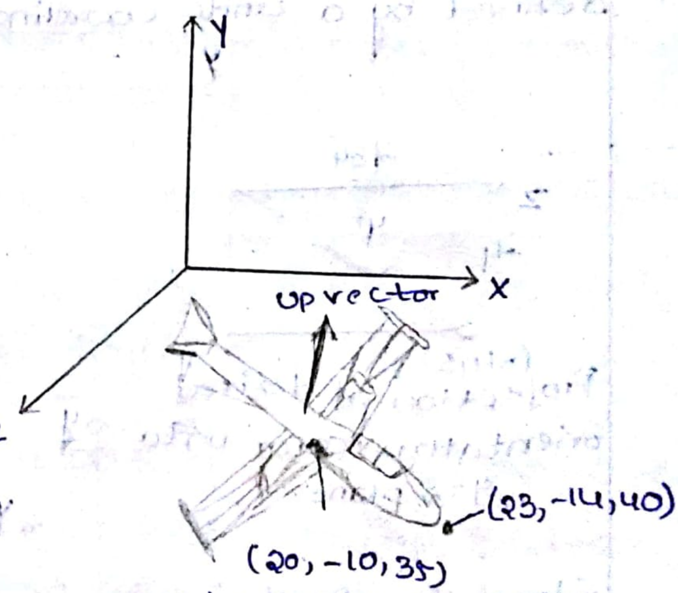
⑤ Write about fixed angle representation used to show orientation?

A: * **Fixed Angle Representation:**

- One way to represent an orientation is as a series of rotations around the principal axes (the fixed angle representation).
- For ex, an aircraft, is originally defined at origin, its nose pointed down the z-axis and its upvector in +ve y-axis.
- Now imagine that the desire is to position the aircraft in world space so that its center is at (20, -10, 35) and nose is oriented toward (23, -14, 40) & upvector is pointed in general y-axis.



Object Space definition



world space position and orientation of aircraft.

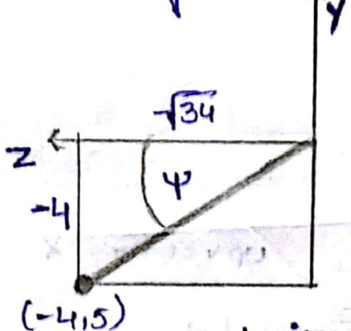
- The task is to determine the representation of the transformation from the aircraft's object space definition to its desired position and orientation in world space.
- The transformation can be decomposed into a rotation followed by a translation of (20, -10, 35). The rotation will transform the aircraft to an orientation so that, with its center at the origin, its nose is oriented toward (23-20, -14+10, 40-35) = (3, -4, 5); this will be referred to as aircraft's orientation vector.

• To rotate the object to line up with the projected vec, a positive x-axis rotation with $\sin\varphi = -4/\sqrt{50}$ and $\cos\varphi = 34/\sqrt{50}$ is required.

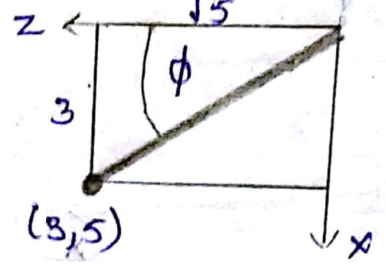
• To rotate the aircraft, a +ve y-axis rotation with $\sin\phi = 3/\sqrt{34}$ and $\cos\phi = 5/\sqrt{34}$ is required.

• An alternative way to represent a transformation to a desired orientation is to construct what is known as the "matrix of desired direction cosines."

• Consider the transforming a copy of the global coordinate system so that it coincides with a desired orientation defined by a unite coordinate system.

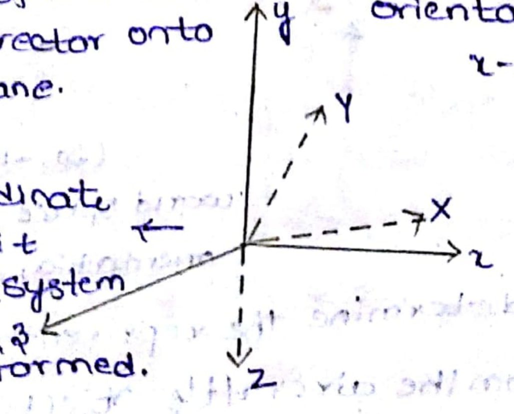


Projection of desired orientation vector onto y-z plane.



Projection of desired orientation vector onto x-z plane.

Global coordinate systems & Unit coordinate system to be transformed.



x, y, z - global coordinate system

X, Y, Z - desired orientation defined by unit coordinate system

• To construct this matrix, note that the transformation matrix, M should do the following mappings:

$X = M \cdot x$ $\qquad$ $Y = M \cdot y$ $\qquad$ $Z = M \cdot z$

$$\begin{bmatrix} X_x \\ X_y \\ X_z \end{bmatrix} = M \cdot \begin{bmatrix} 1 \\ 0 \\ 0 \end{bmatrix} \qquad \begin{bmatrix} Y_x \\ Y_y \\ Y_z \end{bmatrix} = M \cdot \begin{bmatrix} 0 \\ 1 \\ 0 \end{bmatrix} \qquad \begin{bmatrix} Z_x \\ Z_y \\ Z_z \end{bmatrix} = M \cdot \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix}$$

$$\begin{bmatrix} X_x & Y_x & Z_x \\ X_y & Y_y & Z_y \\ X_z & Y_z & Z_z \end{bmatrix} = M \cdot \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} X_x & Y_x & Z_x \\ X_y & Y_y & Z_y \\ X_z & Y_z & Z_z \end{bmatrix} = M$$

• In the ex of transforming the aircraft, the desired z-axis is the desired orientation vector. With the assumption that there is no longitudinal rotation, the desired x-axis can be formed by taking the cross product of the original y-axis & desired z-axis. The desired y-axis can then be formed by taking the cross product of desired z-axis & desired x-axis. Each of these is divided by its length to form unit vectors.

(6) Explain the following:
a) Roles of various departments involved in making production?
b) Ortho Normalization?

A: a) Roles of various departments involved in making production:

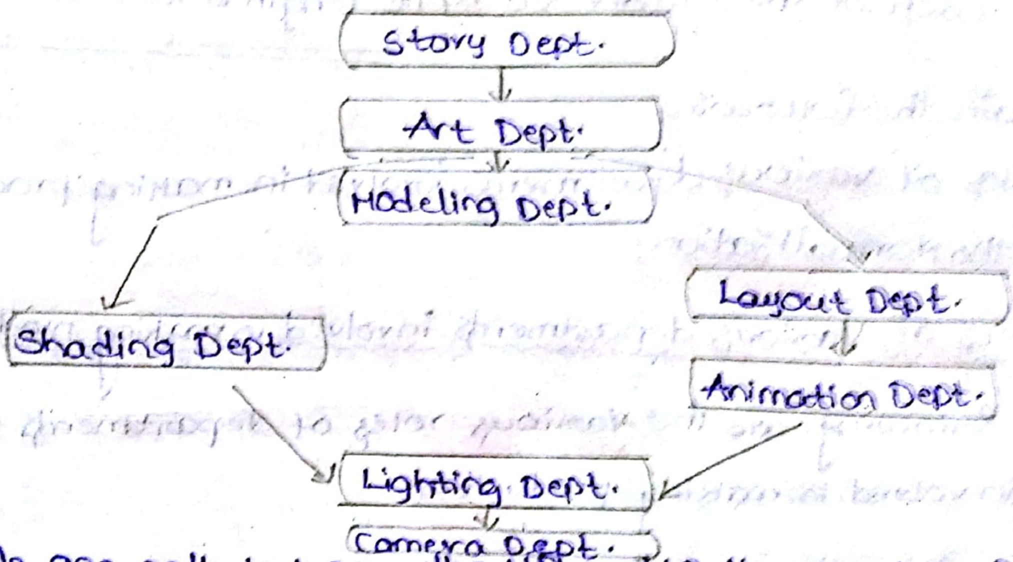
The following are the various roles of departments which are involved in making production:

Story Department: It translates the verbal into the visual. The screenplay enters the Story Department, the storyboard is developed and the story reel leaves. It goes to the Art Department.

Art Department: It is, working from the storyboard, creates the designs and color studies for the film, including detailed model description and lighting scenarios. The Art Department develops a consistent look to be used in the imagery. This look guides the Modeling, layout and Shading Departments.

Modeling Department: It creates the characters and the world in which they live. Every brick and stick to appear in the film must be handcrafted. Often, articulated figures or other models with inherint movements are created as the parameterized models. Parameters are defined that control possible articulations or other movements for the figure. This facilities the ability of animators to stay on the model, ensuring that animation remains consistent with the concept of the model. The models are given to Layout & Shading.

Layout Department: It is responsible for taking the film from two dimensions to three dimensions. This guides the Animation Department.



• On one path between the MD and LD lies Shading. It must translate the attributes of the object that relate to its visual appearance into texture maps, displacement shaders, and lighting models.

• On another path between Modeling & Lighting lies Layout, followed by Animation. Working from audio, the story & the blocking & staging produced by Layout, the AD is responsible for bringing the characters to life.

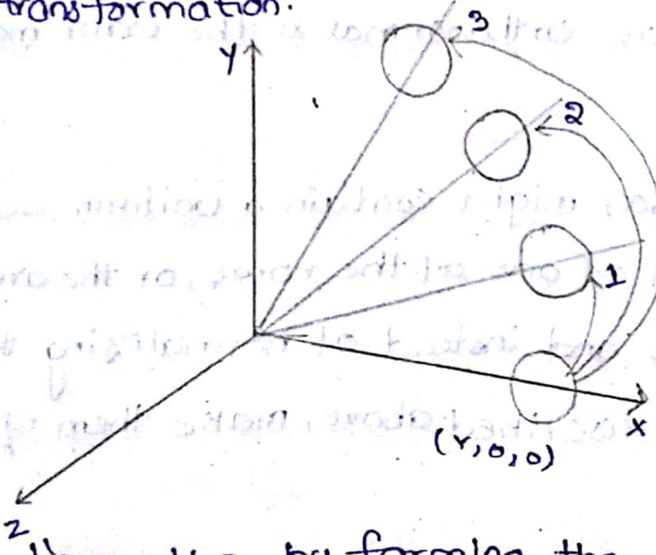
Lighting Department: It assigns to each sequence teams that have responsibility for translating the AD's vision to digital entity. At this point the animation & camera placement have been done.

Camera Department: It is responsible for actually rendering the frames during Toy story, pixar used a dedicated array of hundreads of processors called the Render Faam.

b) OrthoNormalization:

• The rows of a matrix that represent a rigid transformation are ⊥ar to each other and are of unit length. The same can be said of the matrix columns.

• If values in a rigid transformation matrix have accumulated errors, then the rows cease to be orthonormal & the matrix ceases to represent a rigid transformation; it will have the effect of introducing shear into the transformation.




```
y = 0
repeat until(done){
R = y-axis rotation matrix of 'y' degrees
for each point P of the moon{
    P' = R*P
}
recorded a frame of the animation
y = y+5
}
```

"Rotation by forming the rotation matrix a new for each frame"

• However, if it is known that the matrix is supposed to represent a rigid transformation, it can be messaged back to a rigid transformation matrix.

• A rigid transformation matrix has an upper 3×3 sub-matrix with specific properties: the rows (columns) are unit vectors orthogonal to each other.

• A simple procedure to reformulate the transformation matrix to represent a rigid transformation is to take the first row & normalize it.

- Take the second row (column), ~~norma~~ compute the cross product of this row (column) & the first row (column), normalize it, and place it in the third row (column).

- Take the cross product of the third row (column) and the first (column) row, normalize it, and put it in the second row (column).

- Note that this doesn't necessarily produce the correct transformation; it merely forces the matrix to represent a rigid transformation.

- The error has just been shifted around so that the columns of matrix are orthonormal & the error may be less noticeble.

- If the transformation might contain a uniform scale, then take the length of one of the rows, or the average length of three rows and instead of normalizing the vectors by the steps described above, make them equal to its length.

- If the transformation might include nonuniform scale then the difference between shear and error accumulation can't be determined unless something more is known about the transformation represented.