Java 3D and Games Programming

- Introduction to 3D graphics concepts
  - 3D Coordinates
- 3D graphics programming
  - Low and high level approaches
- Java 3D
  - The scene graph
- Modelling 3D objects
  - Polygons
- Interaction and animation
  - Behaviours
  - Collision detection
- Lighting
  - Shading models
How Do We Create 3D Scenes?

Project 3D World to 2D Screen

(Java 3D Tutorial Chapt 1 Fig 1-9)
Previous material discussed 2D gaming with 2 co-ordinates denoted by 'x' and 'y' that specify positions along the 'x' and 'y' axis.

- `drawLine(x1,y1,x2,y2);`

We now wish to add a 3rd dimension on what we shall call the 'z' axis. The 'z' axis effectively defines the depth of a point.

There are 2 main co-ordinate systems in 3D programming which effectively define whether positive values of 'z' move a point towards you or away from you.

- Left handed, z increases as you move away from viewer
  Positive rotation is clockwise about axis of rotation
3D Co-ordinate Systems - 3

- Right handed, z increases as you move toward viewer
  Positive rotation is anti-clockwise about axis of rotation
  - Java 3D

The View Window

When displaying a 3D scene, an application provides a 2D 'View Window' into the 3D world. As the user moves around, this 2D view changes.
The View Frustum

Depending on how close to the 'View Window' the observer viewpoint is projected to be, we get a broad or narrow 4 sided pyramid defining the visible area the user can see. This is called the 'View Frustum'.

Projecting a Point - 1

It can be seen from the diagram of the view window that we can draw a line from a point on our 3D object that passes through the View Window. The View Window is a 2D space which means we are projecting from a 3D co-ordinate into a 2D co-ordinate. How do we do this?
**Projecting a Point - 2**

Object is distance $z$ along the $z$-axis from viewer. 
And distance $x$ along the $x$-axis. 
View window is distance $d$ from viewer. 
What is point $x'$ along the $x$-axis on the window? 
This is a right angle triangle problem...

![Diagram of point projection]

**Projecting a Point - 3**

We need to work out what the proportional value of $x$ on the View Window is (we call this $x'$). It is in the same ratio as the viewing distance 'd' is to the actual distance 'z'. We know both 'd' and 'z' so:

$$x' = \frac{d}{z} \times x$$

![Diagram of point projection]
Formula for 3D Graphics

1. Establish a coordinate system and its origin (0,0,0)
2. Specify size and position of view window and viewpoint (establish view frustum)
3. Draw object in 3D world coordinates e.g. drawCube(x,y,z,height,width,depth);
4. Project 3D object onto 2D array of screen pixels

The End