7.5.4 Gimbal Lock

Let's take another example starting from the point where the two axial systems are mutually aligned. Figure 7.12 shows the orientation of $X'Y'Z'$ after it is subjected to a roll of 45° about the z-axis, and Fig. 7.13 shows the orientation of $X'Y'Z'$ after it is subjected to a pitch of 90° about the x-axis. Now the interesting thing about this orientation is that if we now performed a yaw of 45° about the z-axis, it would rotate the x'-axis towards the x-axis, counteracting the effect of the original roll. yaw has become a negative roll rotation, caused by the 90° pitch. This situation is known as *gimbal lock*, because one degree of rotational freedom has been lost. Quite innocently, we have stumbled across one of the major weaknesses of Euler

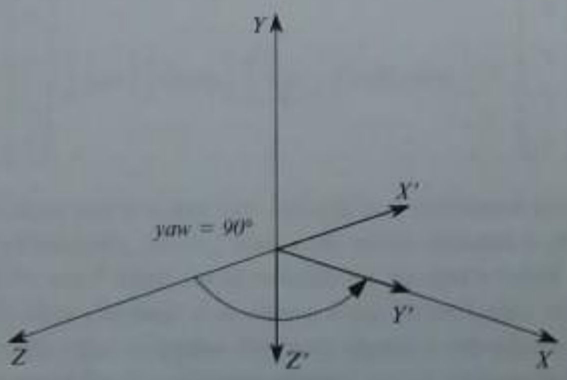

Fig. 7.11 The $X'Y'Z'$ axial system after a *yaw* of 90°.

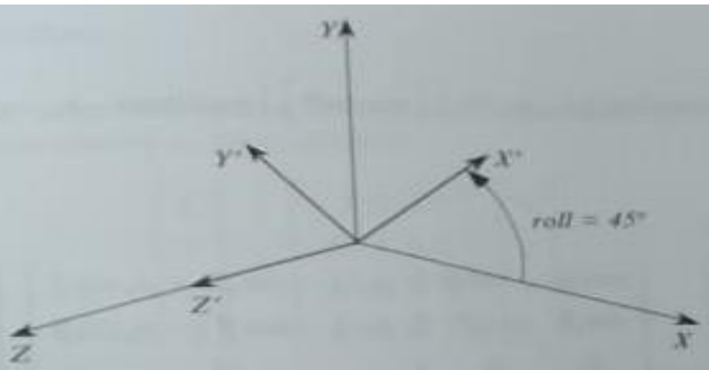

Fig. 7.12 The $X'Y'Z'$ axial system after a *roll* of 45°.

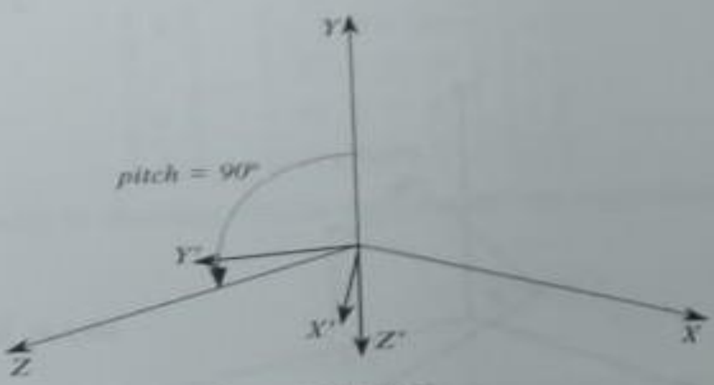

Fig. 7.13 The $X'Y'Z'$ axial system after a *pitch* of 90°.

angles: under certain conditions it is only possible to rotate an object about two axes. One way of preventing this is to create a secondary set of axes constructed from three orthogonal vectors that are also rotated alongside an object or virtual camera. But instead of making the rotations relative to the fixed frame of reference, the roll, pitch and yaw rotations are relative to the rotating frame of reference. Another method is to use quaternions, which will be investigated later in this chapter.