

SAMS 2018

Mechanisms in Motion

Degrees of Freedom (DOF)

This lab is adapted from the tutorial <https://learnengineering.org/understanding-degrees-of-freedom/>

The Degrees of Freedom (DOF) tells you how many variables are required to determine position of a mechanism in space.

Consider the mechanism in Figure 1a. The position of this 4-bar mechanism can be completely determined by knowing either the angle or position of any one of the other members. So, the DOF of this mechanism is 1. (Why is it a 4-bar linkage when there are only three links that can move?)

Similarly, for the cam and follower mechanism in Figure 1b, the DOF is also 1. This is a little tricky because if I tell you the height of the follower, the cam could be tilted to the right or the left, but because the follower can only move up and down in the y direction, the mechanism has 1 DOF.

In Figure 1c, to determine position of the slider crank mechanism, you need to know the angle or displacement of at least 2 members. So here, the degrees of freedom is 2.

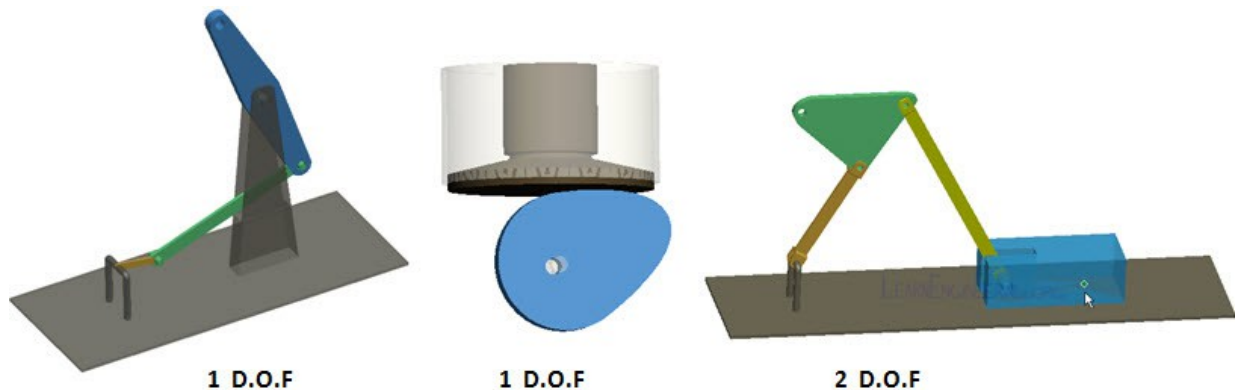


Fig.1 Examples of degrees of freedom of different mechanisms

Note: The DOF tells you more about the control of a mechanism than about its motion. The end of the 4 bar mechanism in Figure 1a moves in an arc in the y plane, and the slider in Figure 1c moves in a line in the x plane, but the 4-bar linkage has 1 DOF and the slider has 2.

1. Degrees of Freedom of a Rigid Body

Consider the I-beam below, which is floating in space. It could have 3 linear motions; that is, it could move in the x direction, the y direction or the z direction. It could also rotate around the x axis, the y axis or the z axis, which gives it 3 more motions. In total, you need 6 inputs to determine its position. That is, you need to know its x , y , and z coordinates and its rotation angle around each of its axes to know exactly where it is in space. Therefore, the DOF of a rigid body in space is 6.

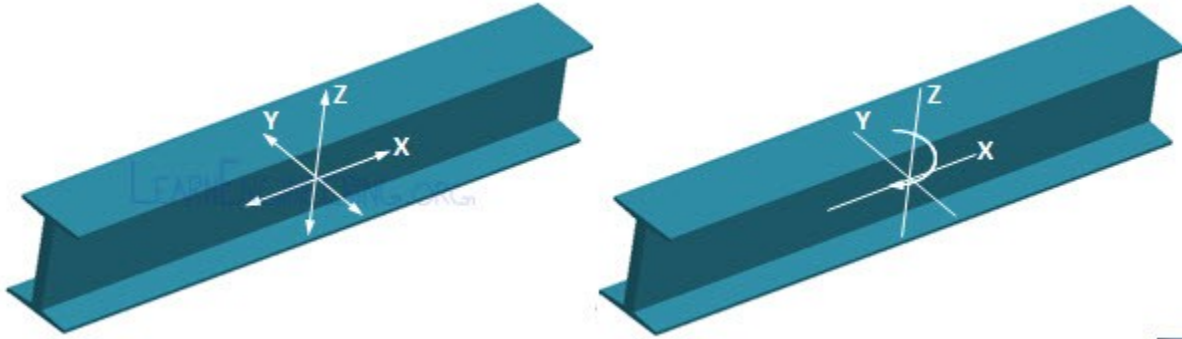


Fig.2 A rigid body in space has 6 degrees of freedom

If a rigid body rests on a plane, you have to specify its x and y positions and its rotation around z . The plane keeps it from rotating in x and y or from moving in the z direction. So the DOF of a rigid body in a plane is 3.

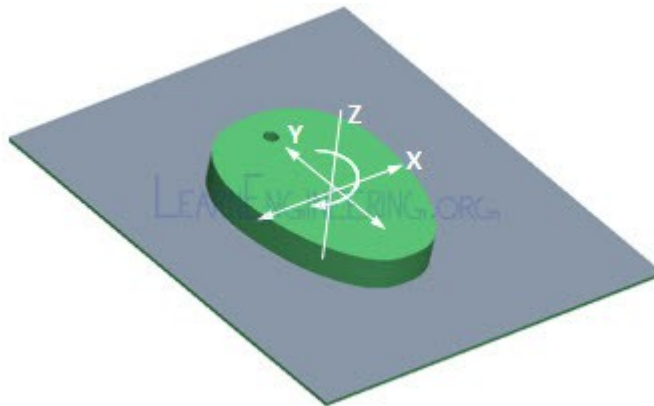


Fig.3 A rigid body on plane has 3 degrees of freedom