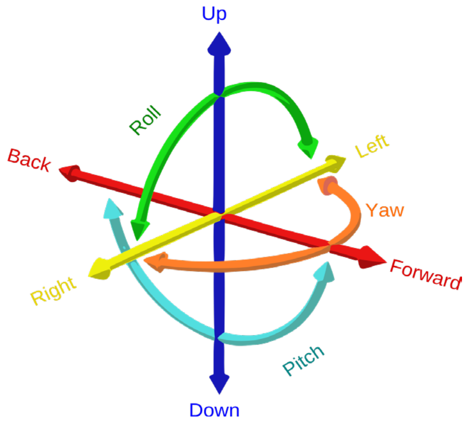
Six degrees of freedom

Six degrees of freedom (or DoF) refers to the freedom a rigid body has to move in a three-dimensional space. In other words, the body is free to change position on the X, Y and Z axes of the Cartesian plane as forward/backward (**surge**), up/down (**heave**), left/right (**sway**) as well as to change orientation between those axes through rotation, usually called **pitch** (transverse axis), **yaw** (normal axis), and **roll** (longitudinal axis). A good example is the Space Shuttle. It can move along the three axes, but it has three more movements: it can roll on the x-axis, it can pitch forward or backward on the y-axis and it can rotate in a circle on the z-axis.

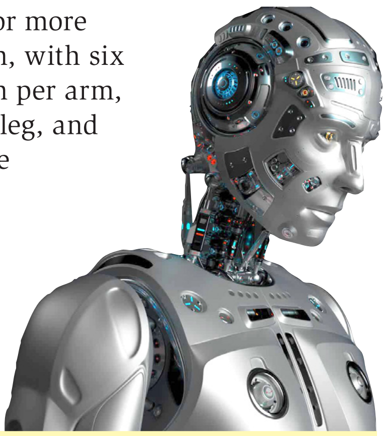


In 1989, Kamen founded FIRST (For Inspiration and Recognition of Science and Technology), an organisation aimed at increasing students' interest in science, technology, and the organisation of robotics competitions.

Humanoid robots are robots with a shape that resembles the human body. Their shape can be functional for specific tasks.

Robots

Serial and parallel manipulator systems are the most common industrial robots and are designed as a series of links connected by motor-powered joints that extend from a base to an end-effector. They usually have an anthropomorphic arm structure as they are described as having a «shoulder», an «elbow» and a «wrist». They are generally designed to position an end-effector with six degrees of freedom, consisting of three in translation and three in orientation.
As the number of DoF typically refers to the number of single-axis rotational joints in the arm, a higher number of joints indicates an increased flexibility in positioning a tool. In 2007, Dean Kamen•, the American engineer who invented the Segway, unveiled the prototype of a robotic arm with 14 degrees of freedom. Humanoid robots•• typically have 30 or more degrees of freedom, with six degrees of freedom per arm, five or six in each leg, and several more in the torso and neck.



Humanoid robot

to heave: *sollevare*
to pitch: *lanciare*
to roll: *rotolare*
to surge: *impennarsi*
to sway: *oscillare*
to yaw: *cambiare direzione*

1 **Match each term or expression with the right definition.**

1. To roll ☐
2. Humanoid ☐
3. Serial manipulator ☐
4. Pitch ☐
5. To heave ☐
6. DoF ☐
7. To manipulate ☐
8. A joint ☐

a. A robot with human-like shape.
b. Degrees of movement in a space.
c. An articulation of a segment.
d. Robots with series of links connected by motor-powered joints.
e. To move up and down on the Cartesian axis.
f. To physically handle an object.
g. To move on a longitudinal axis.
h. Transverse axis.

2 **Answer the questions.**

1. Why is the Space Shuttle a good example of six DoF?
2. Why are robots described as having an anthropomorphic arm?
3. Why do serial robots have six joints?
4. In an end-effect manipulator, what do six DoF consist of?
5. In a robotic arm, what does the number of DoF refer to?
6. In a humanoid robot, how are the DoF distributed along the structure?

3 **Write a brief summary of the following text. Use between 60 and 80 words.**

Mechanics in Humanoids

The mechanical structure is an important aspect in the development of a humanoid robot. A good balance between stiffness and elasticity decides the flexibility of the structure. The main aim is to design a humanoid structure that can easily manipulate and handle objects and can function in different situations as a human would. While designing a humanoid robot, many parameters have to be taken into consideration. These parameters include the design of the links, the types of joint, the forces on each joint, the degrees of freedom of each link, the mass and height of the body and the shape of the "brain". Since the movement of all the links are controlled by processors fixed in the brain, the humanoid's brain computes the controllable signals and sends them to different locations. Material selection is also an important issue for the fabrication of a humanoid. Its metal structure makes it very heavy and materials have to be chosen accurately. The base of humanoids is typically made of stainless steel, while the outer structure is made of strong fibres. The entire structure has a high resistance and an adequate stiffness. The basic design process must analyse the payload and the atmospheric pressure, which will act on the humanoid. It is also fundamental to give the body a rotation of 360 degrees, so that the humanoid can move backwards quickly and easily.

Adapted from: *https://www.researchgate.net/publication/236023351*

payload: *carico utile*