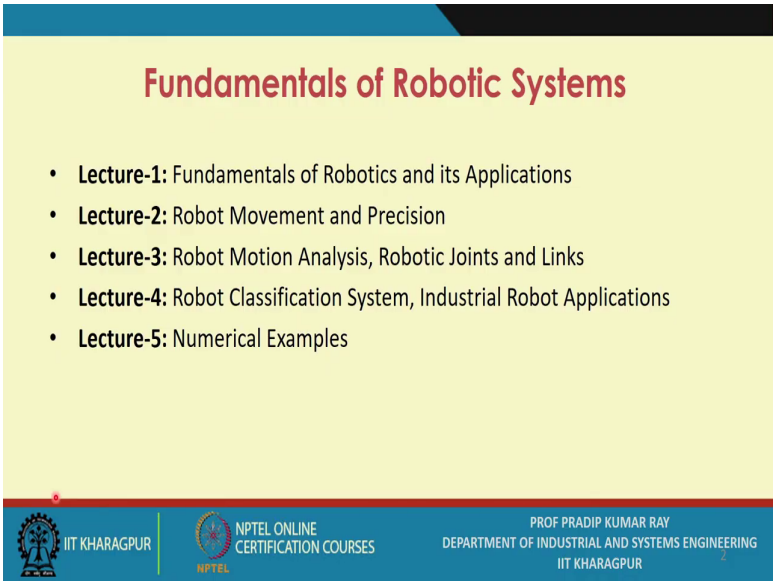
Automation in Production Systems and Management
Prof. Pradip Kumar Ray
Vinod Gupta School of Management
Department of Industrial and Systems Engineering
Indian Institute of Technology, Kharagpur

Fundamentals of Robotic Systems
Lecture - 46
Fundamentals of Robotics and its Applications

(Refer Slide Time: 02:46)



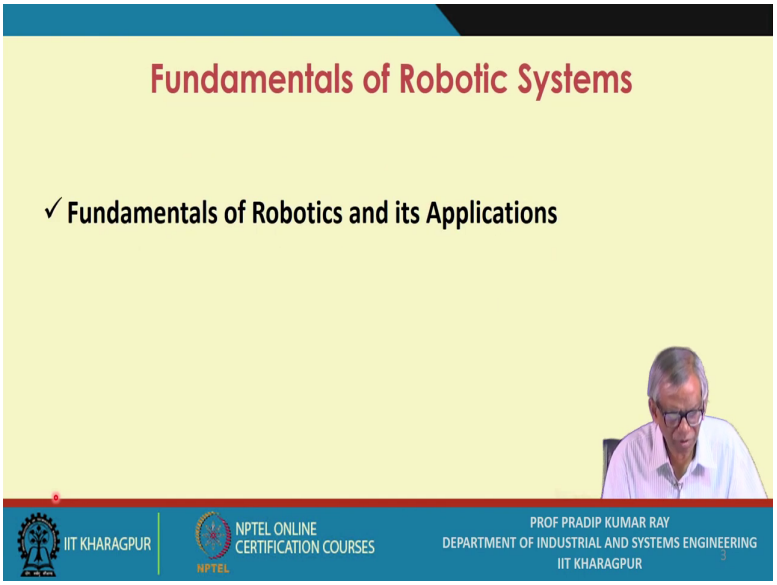
In the lecture 1, we will be highlighting the fundamentals of the robotics and its application.

In lecture 2, we will be the discussing the robot movement and the precision. In the 3rd lecture sessions, we will discuss the robot motion analysis, the robotic joints and links.

In the 4th lecture session, we will discuss robot classification system, industrial robot application.

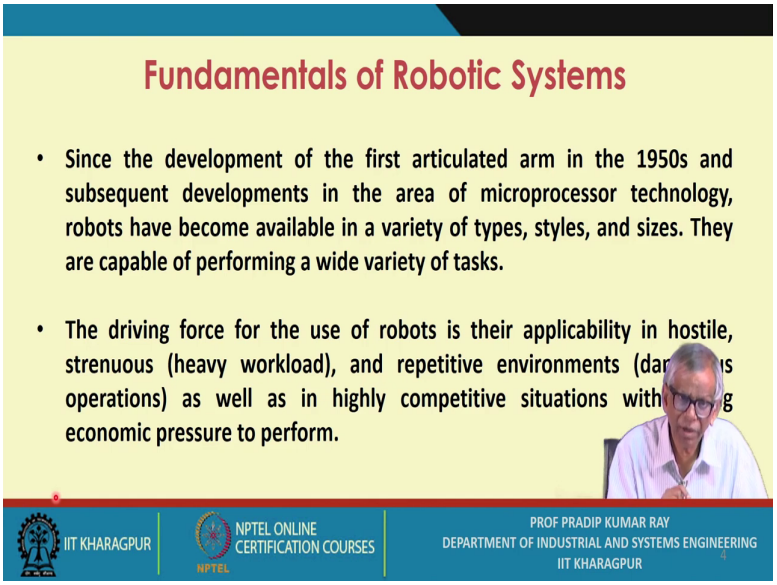
And in the last lecture there could be several numerical examples.

(Refer Slide Time: 04:53)



You will come to know that under what condition are the robot is to be used. Now, let us talk about the fundamentals of robotics and its applications.

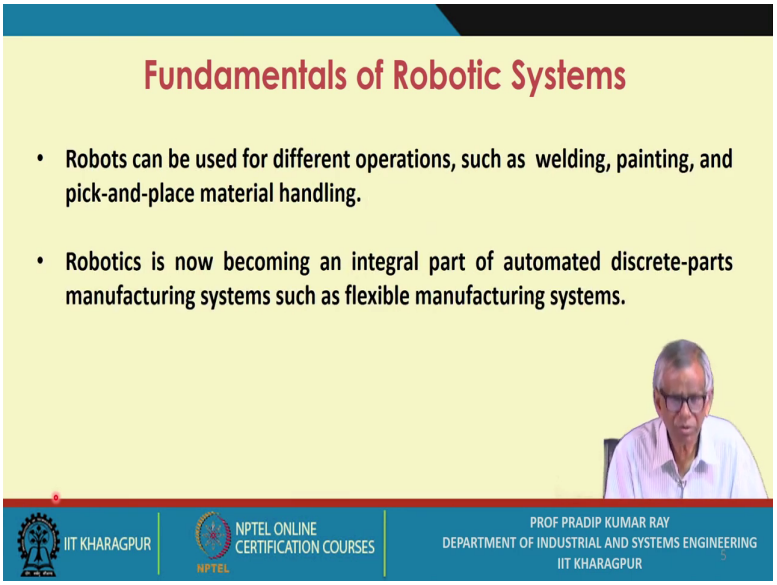
(Refer Slide Time: 05:44)



Since the development of the first articulated arm in the 1950s and subsequent developments in the area of microprocessor technology, robots have become available in a variety of types, styles, and sizes. They are capable of performing a wide variety of tasks.

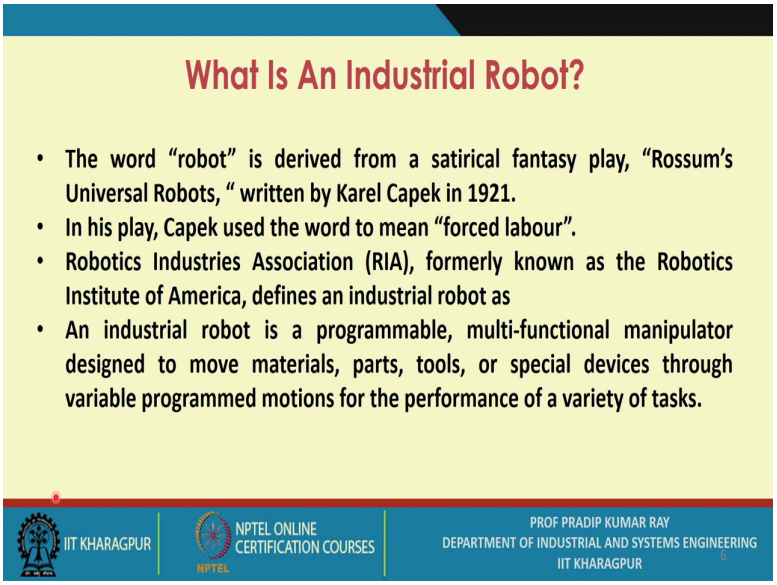
The driving force for the purchase of robots is their applicability in hostile, strenuous, and repetitive environments as well as in highly competitive situations with strong economic pressure to perform.

(Refer Slide Time: 12:51)



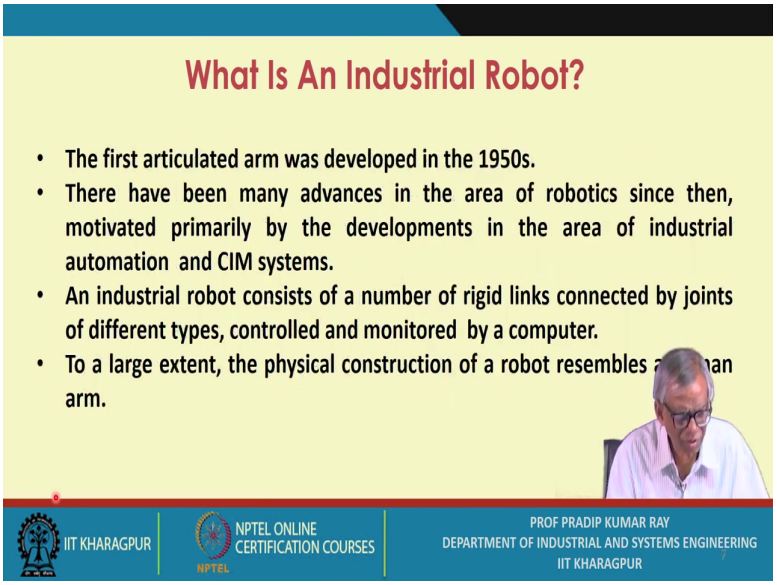
Robots can be used for different operations such as welding, painting and pick and place material handling. It is basically repetitive and simple operation. Robotics is now becoming an integral part of automated discrete parts manufacturing systems.

(Refer Slide Time: 14:49)



The word "robot" is derived from a satirical fantasy play, "Rossum's Universal Robots, " written by Karel Capek in 1921. In his play, Capek used the word to mean "forced labour". Robotics Industries Association (RIA), formerly known as the Robotics Institute of America. An industrial robot is a programmable, multi-functional manipulator designed to move materials, parts, tools, or special devices through variable programmed motions for the performance of a variety of tasks.

(Refer Slide Time: 20:43)



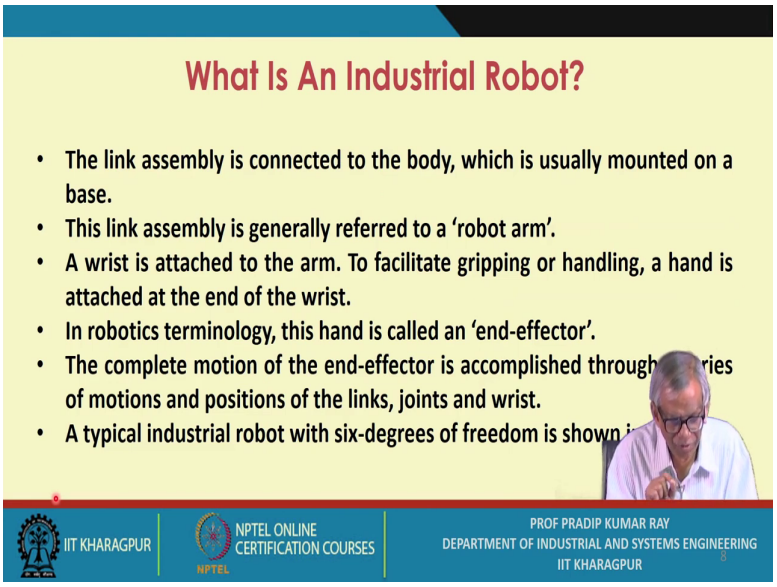
All these operations are to be conducted or to be carried out by a robot. The first articulated arm was developed in 1950s.

There have been many advances in the area of robotics since then, motivated primarily by the developments in the area of industrial automation in particular and computer-integrated manufacturing systems in general.

An industrial robot consists of a number of rigid links connected by joints of different types, controlled and monitored by a computer.

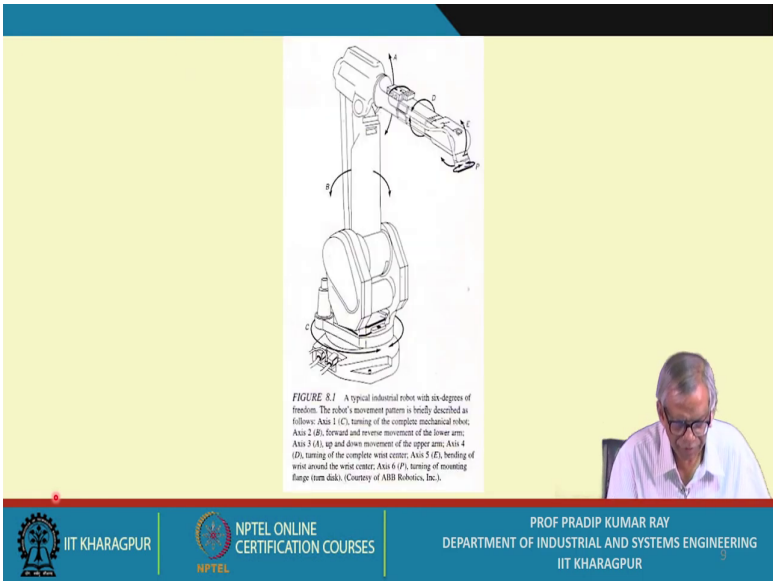
To a large extent, the physical construction of a robot resembles a human arm.

(Refer Slide Time: 22:41)



The link assembly is connected to the body, which is usually mounted on a base. This link assembly is generally referred to a robot arm. A wrist is attached to the arm. To facilitate gripping or handling, a hand is attached at the end of the wrist. In robotics terminology, this hand is called an end-effector. The complete motion of the end-effector is accomplished through a series of motions and positions of the links, joints and wrist. A typical industrial robot with six-degrees of freedom is shown in Figure 8.1.

(Refer Slide Time: 24:28)



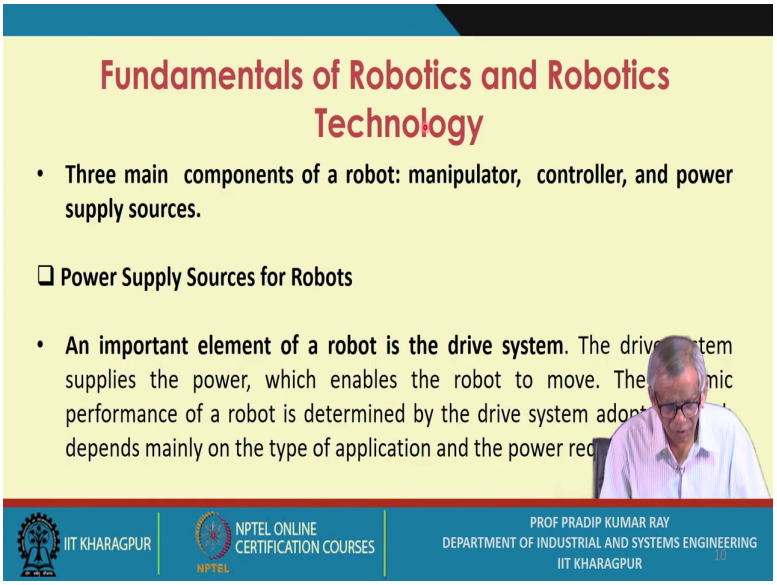
This is the base. This is the lower arm, this is the upper arm, and there is the end effector, there is a wrist. You have the axis C, axis B, axis A, axis D, and axis E.

Axis 1; that is turning of the complex mechanical robot, that is C and that the robot is placed on a base. What is axis B? That is forward and the reverse movement of the lower arm, that is the lower arm and this is the upper arm. Now, you go to axis A; up and down movement of the upper arm.

Accordingly, you have to design the joints. You have the axis D; turning of the complete the wrist center. 360^{o} you can rotate.

C is basically the bending of the wrist around the wrist center. This is the wrist you have around the wrist center, you can bend it.

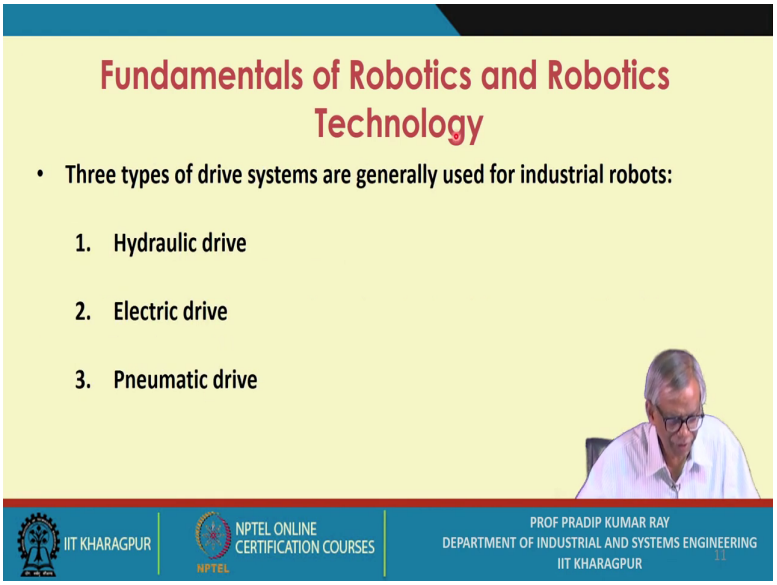
(Refer Slide Time: 26:31)



There are three main components of robot, first one is the manipulator, the second one is the controller, and the third one is the power supply sources.

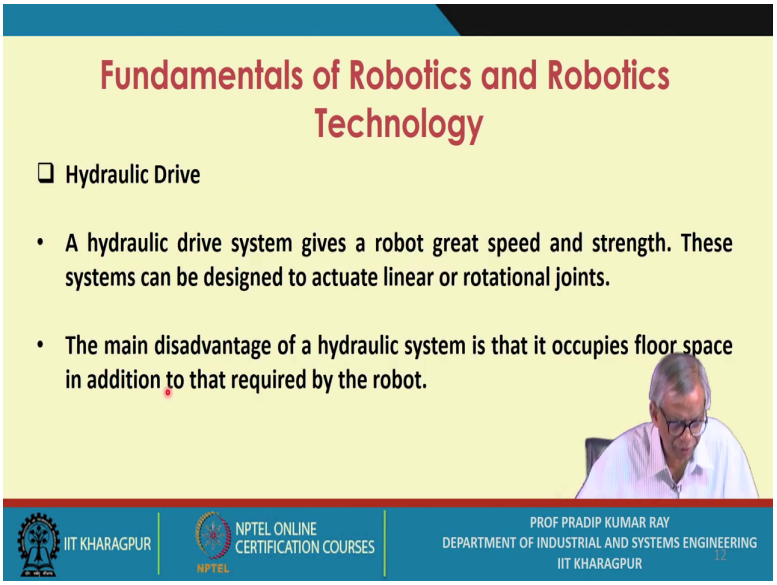
How many different types of the power supply sources you may have for the robots? An important element of a robot is the drive system. The drive system supplies the power, which enables the robot to move. The dynamic performance of the robot is determined by the drive system adopted, which depends mainly on the type of application and the power requirements.

(Refer Slide Time: 27:14)



There are three kinds of drive; first one is the hydraulic drive. Second one is the electric drive and third one is the pneumatic drive.

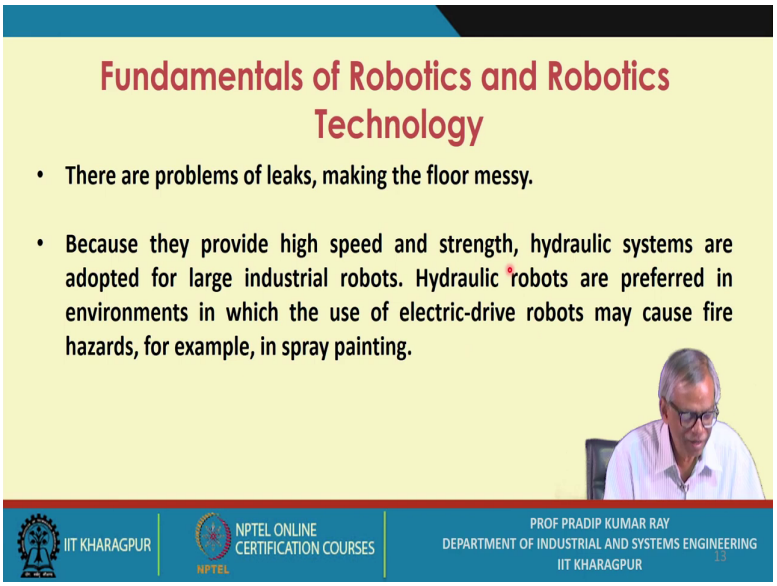
(Refer Slide Time: 27:41)



A hydraulic drive system gives a robot great speed and strength. These systems can be designed to actuate linear or rotational joints.

The main disadvantage of a hydraulic system is that it occupies floor space in addition to that required by the robot.

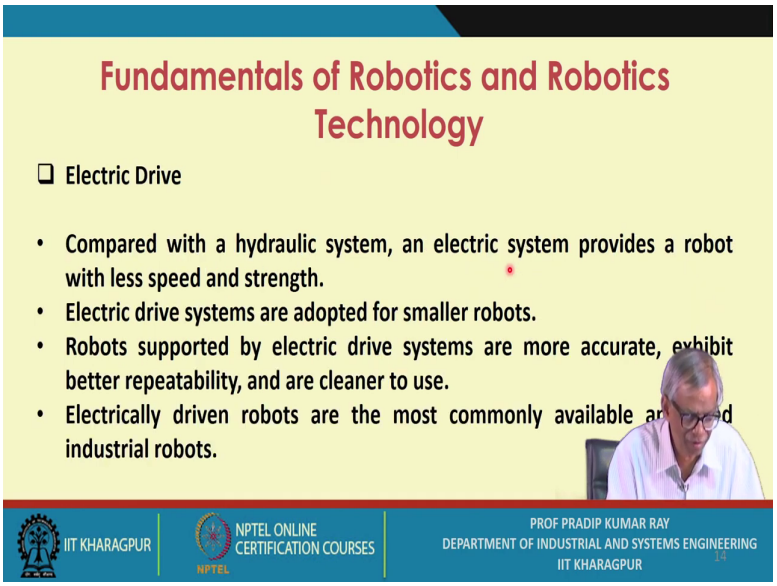
(Refer Slide Time: 28:24)



There are problems of leaks, making the floor messy.

Because they provide high speed and strength, hydraulic systems are adopted for large industrial robots. Hydraulic robots are preferred in environments in which the use of electric-drive robots may cause fire hazards, for example, in spray painting.

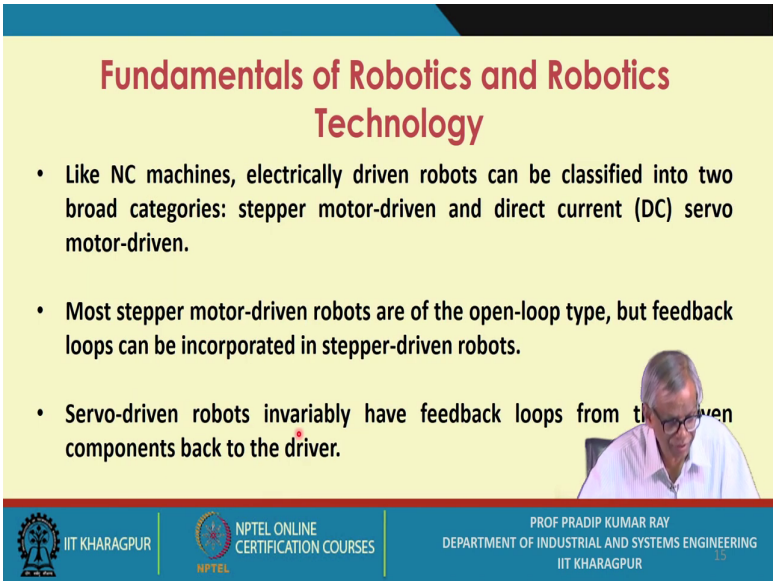
(Refer Slide Time: 29:20)



Next one is Electric drive

Compared with a hydraulic system, an electric system provides a robot with less speed and strength. Electric drive systems are adopted for smaller robots. Robots supported by electric drive systems are more accurate, exhibit better repeatability, and are cleaner to use. Electrically driven robots are the most commonly available and used industrial robots.

(Refer Slide Time: 30:26)

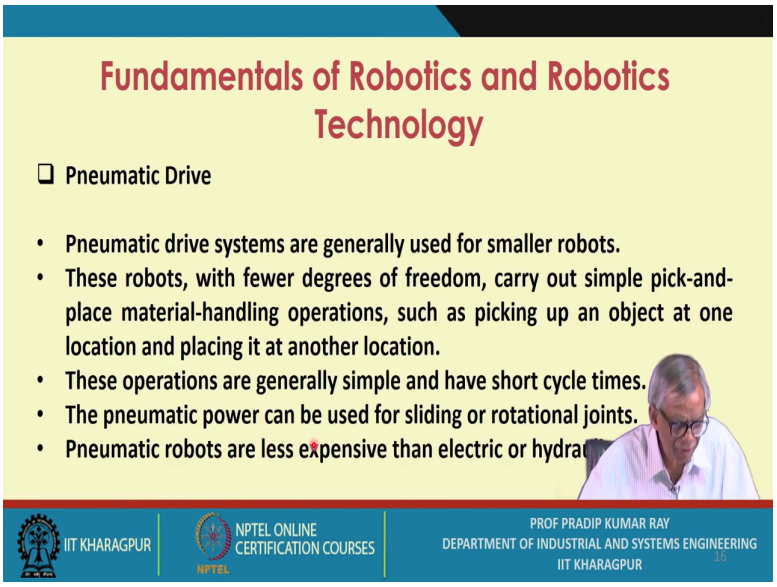


Like numerically controlled (NC) machines, electrically driven robots can be classified into two broad categories: stepper motor-driven and direct current (DC) servo motor-driven.

Most stepper motor-driven robots are of the open-loop type, but feedback loops can be incorporated in stepper-driven robots.

Servo-driven robots invariably have feedback loops from the driven components back to the driver.

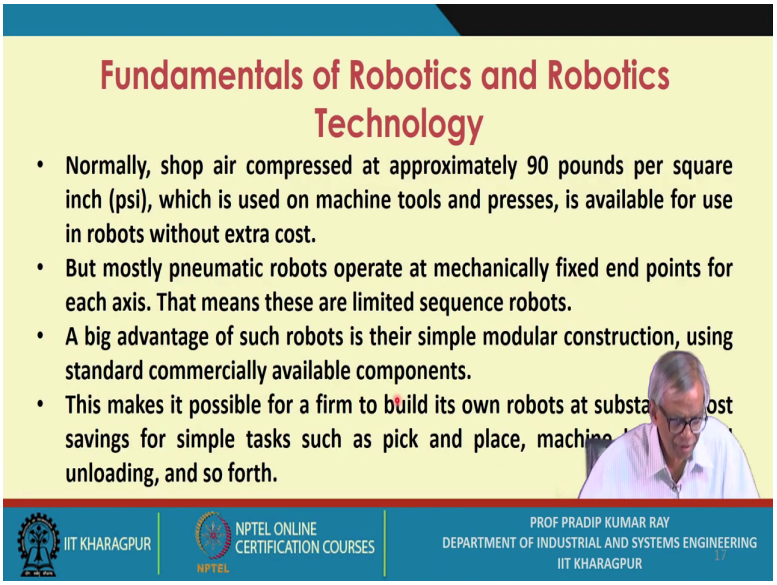
(Refer Slide Time: 30:38)



The last kind of the drive is the pneumatic drive.

Pneumatic drive systems are generally used for smaller robots. These robots, with fewer degrees of freedom, carry out simple pick-and-place material-handling operations, such as picking up an object at one location and placing it at another location. These operations are generally simple and have short cycle times. The pneumatic power can be used for sliding or rotational joints. Pneumatic robots are less expensive than electric or hydraulic robots.

(Refer Slide Time: 31:11)



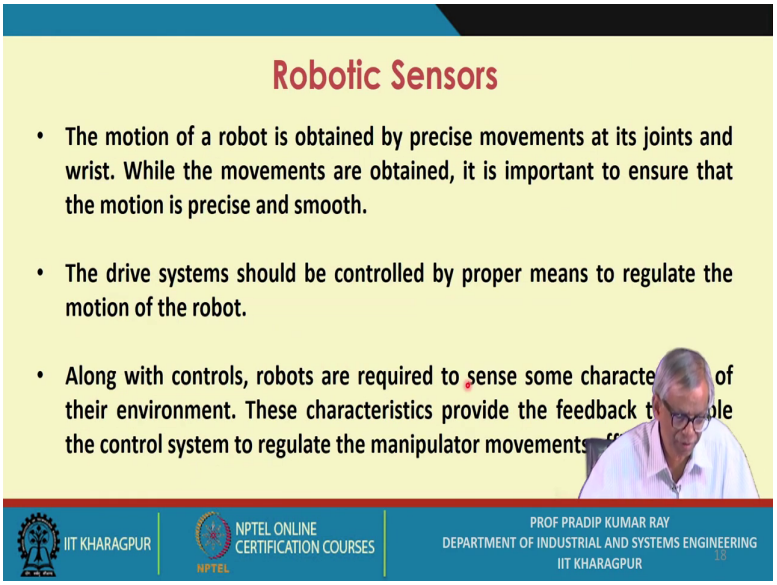
Normally, shop air compressed at approximately 90 pounds per square inch (psi), which is used on machine tools and presses, is available for use in robots without extra cost.

But mostly pneumatic robots operate at mechanically fixed end points for each axis. That means these are limited sequence robots.

A big advantage of such robots is their simple modular construction, using standard commercially available components.

This makes it possible for a firm to build its own robots at substantial cost savings for simple tasks such as pick and place, machine loading and unloading, and so forth.

(Refer Slide Time: 31:33)

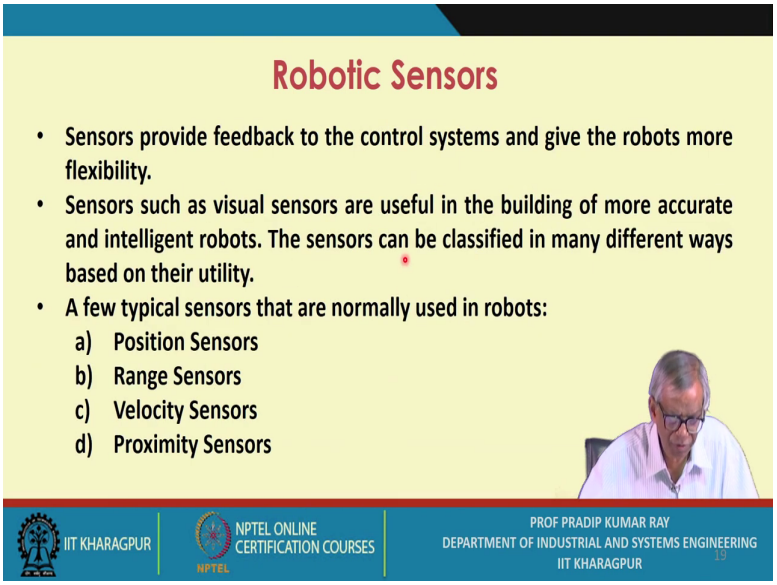


The motion of a robot is obtained by precise movements at its joints and wrist. While the movements are obtained, it is important to ensure that the motion is precise and smooth.

The drive systems should be controlled by proper means to regulate the motion of the robot.

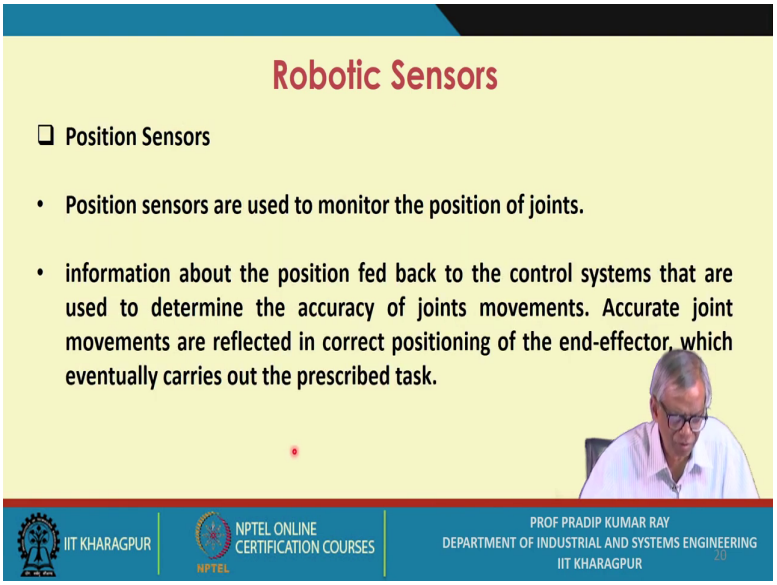
Along with controls, robots are required to sense some characteristics of their environment. These characteristics provide the feedback to enable the control system to regulate the manipulator movements efficiently.

(Refer Slide Time: 31:40)



There are four kinds of the sensors; position sensors, range sensors, velocity sensors, proximity sensors.

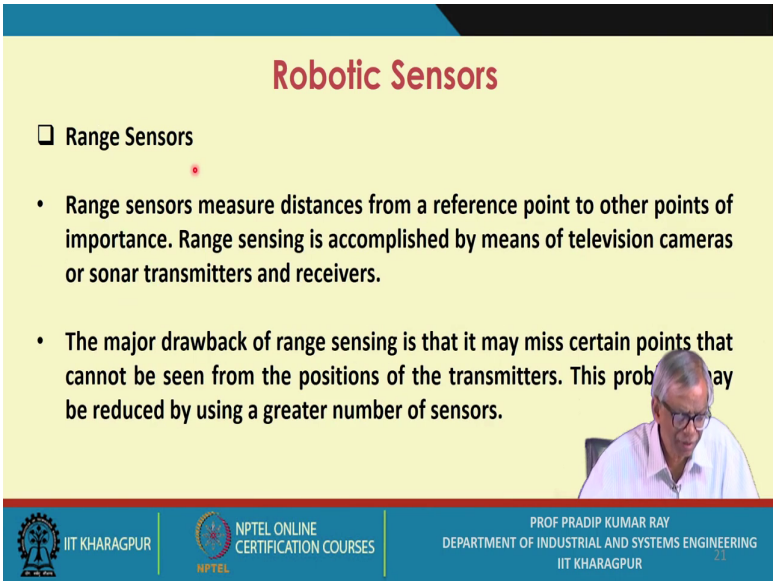
(Refer Slide Time: 31:52)



Position sensors are used to monitor the position of joints. Information about the position fed back to the control systems that are used to determine the accuracy of joints movements.

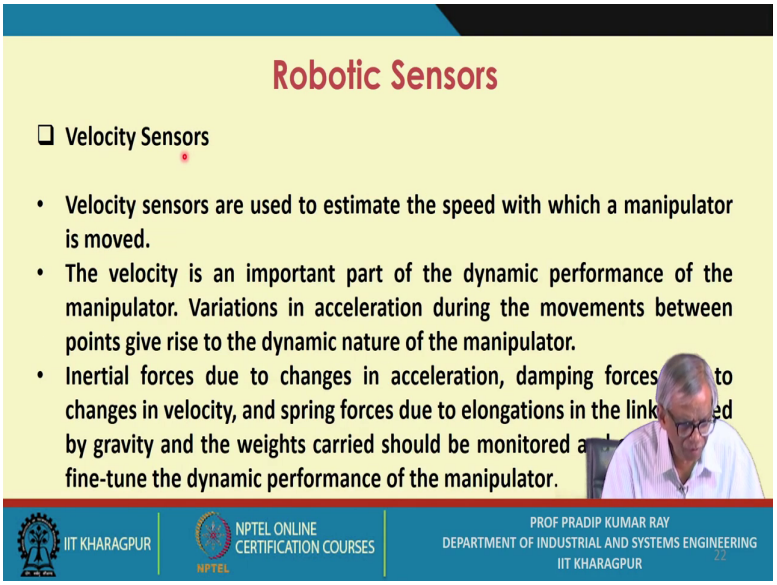
Accurate joint movements are reflected in correct positioning of the end-effector, which eventually carries out the prescribed task.

(Refer Slide Time: 32:01)



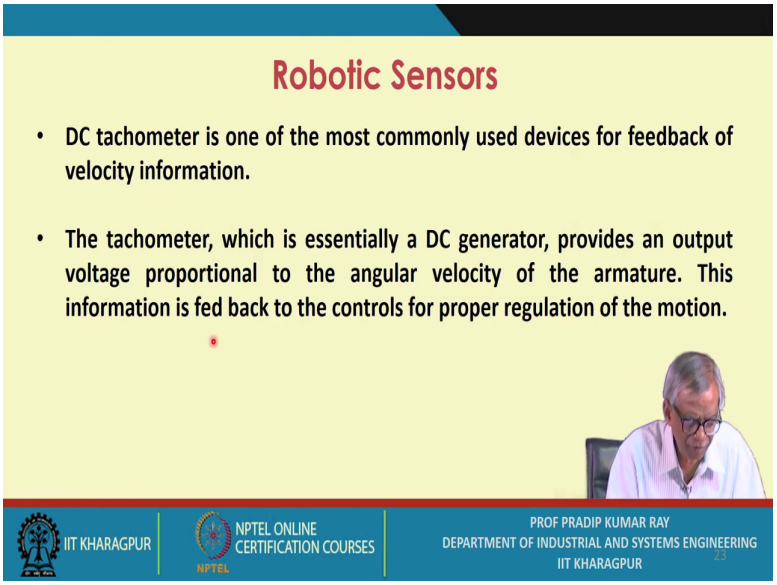
Range sensors measure distances from a reference point to other points of importance. Range sensing is accomplished by means of television cameras or sonar transmitters and receivers. The major drawback of range sensing is that it may miss certain points that cannot be seen from the positions of the transmitters. This problem may be reduced by using a greater number of sensors.

(Refer Slide Time: 32:22)



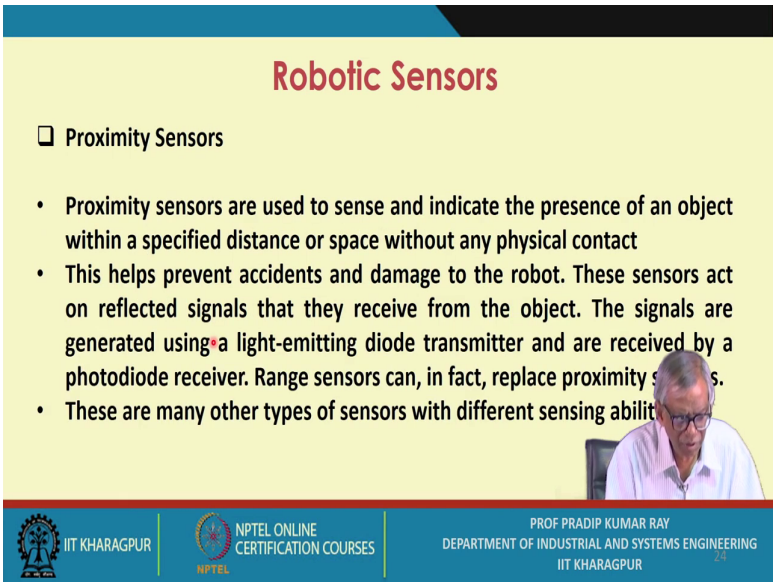
Velocity sensors are used to estimate the speed with which a manipulator is moved. The velocity is an important part of the dynamic performance of the manipulator. Variations in acceleration during the movements between points give rise to the dynamic nature of the manipulator. Inertial forces due to changes in acceleration, damping forces due to changes in velocity, and spring forces due to elongations in the links caused by gravity and the weights carried should be monitored and controlled to fine-tune the dynamic performance of the manipulator.

(Refer Slide Time: 32:50)



The DC techometer is one of the most commonly used devices for feedback of velocity information. The techometer, which is essentially a DC generator, provides an output voltage proportional to the angular velocity of the armature. This information is fed back to the controls for proper regulation of the motion.

(Refer Slide Time: 32:53)

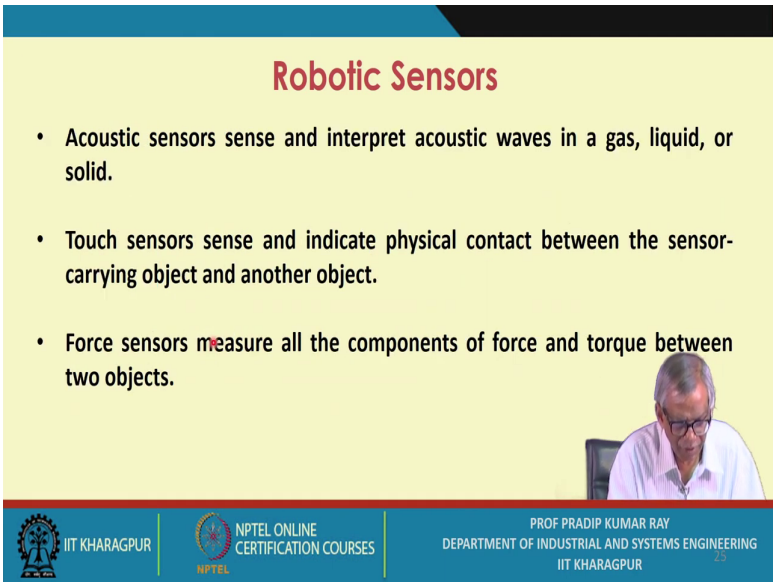


Proximity sensors are used to sense and indicate the presence of an object within a specified distance or space without any physical contact

This helps prevent accidents and damage to the robot. These sensors act on reflected signals that they receive from the object. The signals are generated using a light-emitting diode transmitter and are received by a photodiode receiver. Range sensors can, in fact, replace proximity sensors.

These are many other types of sensors with different sensing abilities.

(Refer Slide Time: 33:15)

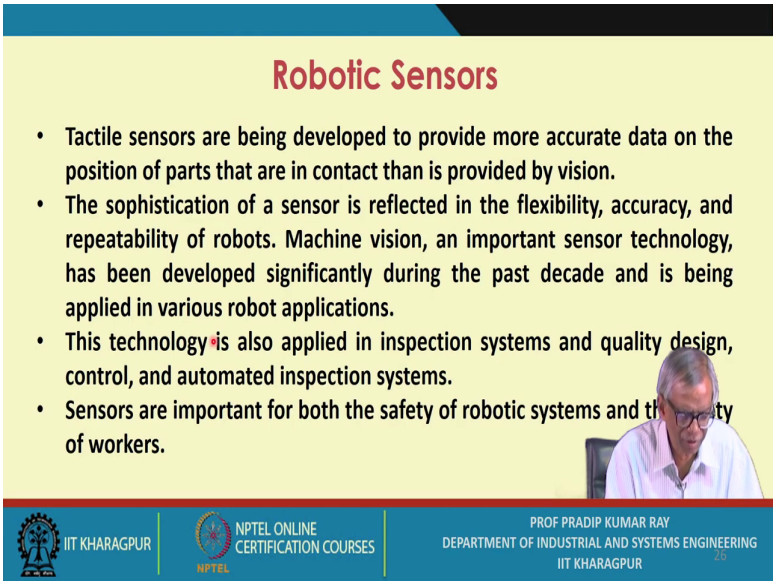


Acoustic sensors sense and interpret acoustic waves in a gas, liquid, or solid.

Touch sensors sense and indicate physical contact between the sensor-carrying object and another object.

Force sensors measure all the components of force and torque between two objects.

(Refer Slide Time: 33:30)



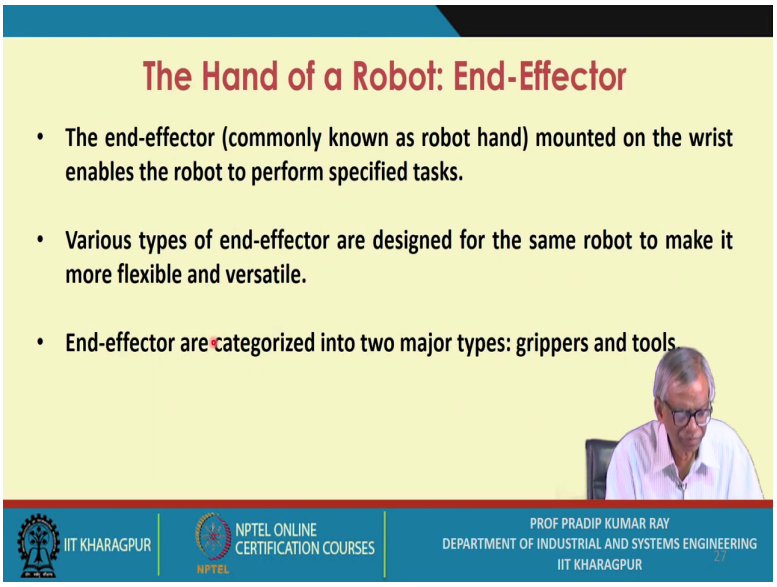
Tactile sensors are being developed to provide more accurate data on the position of parts that are in contact than is provided by vision.

The sophistication of a sensor is reflected in the flexibility, accuracy, and repeatability of robots. Machine vision, an important sensor technology, has been developed significantly during the past decade and is being applied in various robot applications.

This technology is also applied in inspection systems and quality design, control, and automated inspection systems.

Sensors are important for both the safety of robotic systems and the safety of workers.

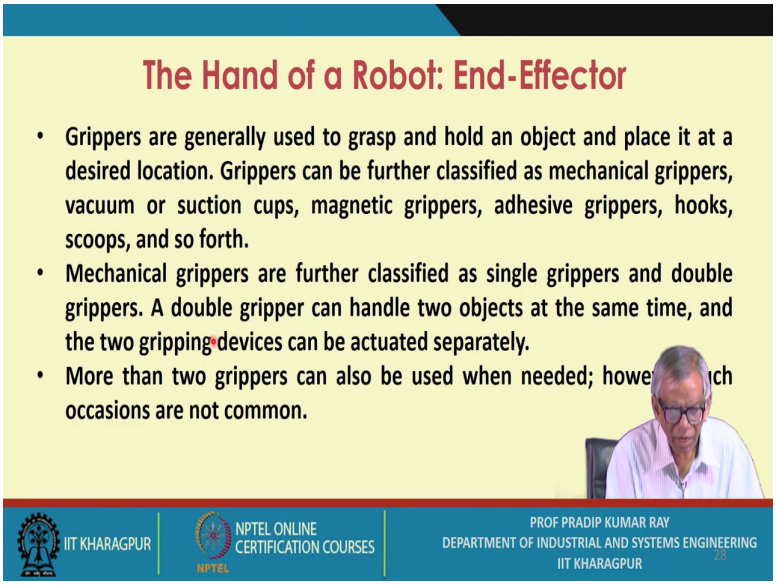
(Refer Slide Time: 33:33)



The end-effector (commonly known as robot hand) mounted on the wrist enables the robot to perform specified tasks.

Various types of end-effector are designed for the same robot to make it more flexible and versatile. End-effector are categorized into two major types: grippers and tools.

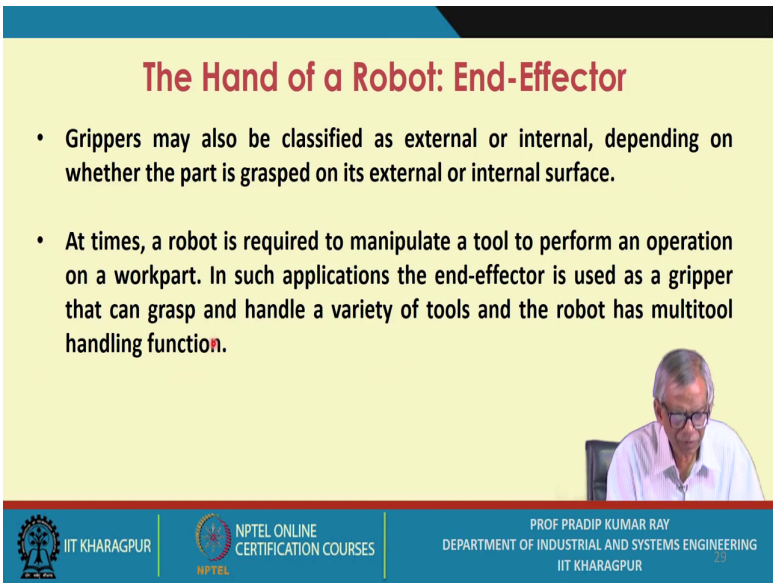
(Refer Slide Time: 33:35)



Grippers are generally used to grasp and hold an object and place it at a desired location. Grippers can be further classified as mechanical grippers, vacuum or suction cups, magnetic grippers, adhesive grippers, hooks, scoops, and so forth.

Mechanical grippers are further classified as single grippers and double grippers. A double gripper can handle two objects at the same time, and the two gripping devices can be actuated separately. More than two grippers can also be used when needed; however, such occasions are not common.

(Refer Slide Time: 33:37)



Grippers may also be classified as external or internal, depending on whether the part is grasped on its external or internal surface.

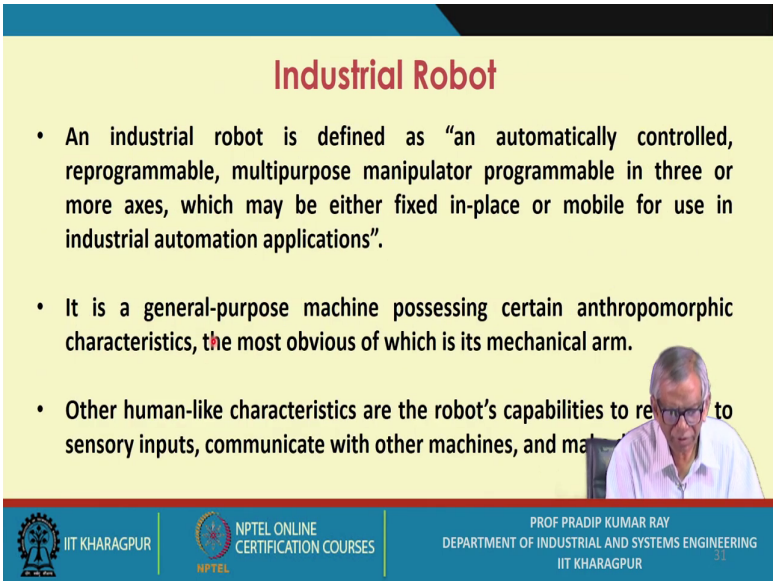
At times, a robot is required to manipulate a tool to perform an operation on a workpart. In such applications the end-effector is used as a gripper that can grasp and handle a variety of tools and the robot has multitool handling function.

(Refer Slide Time: 33:38)

The hand, end effector, all these details are given over here. However, in most robot applications in which only one tool is to be manipulated, the tool is directly mounted on the wrist. Here the tool itself acts as end-effector.

Spot-welding tools, arc-welding tools, spray-painting nozzles, and rotating spindles for drilling and grinding are typical examples of tools used as end-effectors.

(Refer Slide Time: 33:39)

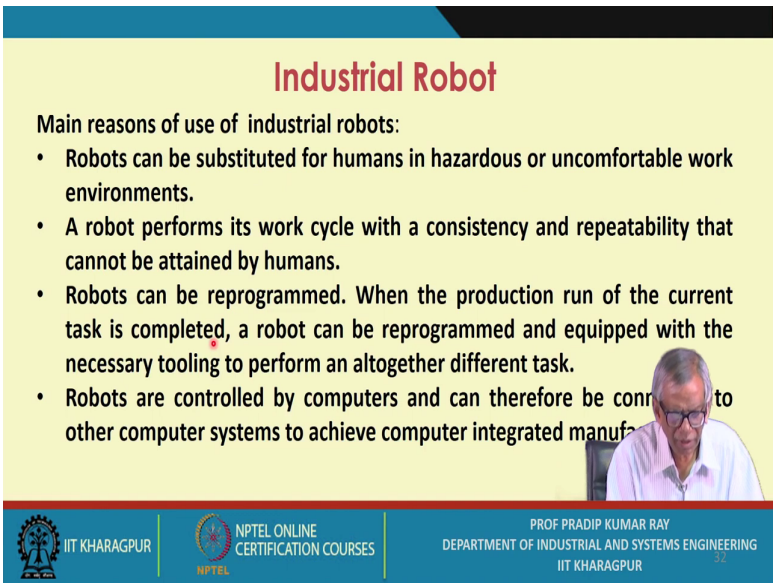


An industrial robot is defined as "an automatically controlled, reprogrammable, multipurpose manipulator programmable in three or more axes, which may be either fixed in-place or mobile for use in industrial automation applications.

It is a general-purpose machine possessing certain anthropomorphic characteristics, the most obvious of which is its mechanical arm.

Other human-like characteristics are the robot's capabilities to respond to sensory inputs, communicate with other machines, and make decisions.

(Refer Slide Time: 33:42)



Some of the qualities that make industrial robots commercially and technologically. important are the following:

1. Robots can be substituted for humans in hazardous or uncomfortable work environments.

2. A robot performs its work cycle with a consistency and repeatability that cannot be attained by humans.

3. Robots can be reprogrammed. When the production run of the current task is completed, a robot can be reprogrammed and equipped with the necessary tooling to perform an altogether different task.

4. Robots are controlled by computers and can therefore be connected to other computer systems to achieve computer integrated manufacturing.

(Refer Slide Time: 34:01)