ROBOT TECHNOLOGY

OBJECTIVE

- Realize the fundamentals of robot technology.
- Know the general characteristics of robots.
- Understand the basic components of robots.
- Recognize robot anatomy.
- Be informed of robot generations.
- Be aware of robot selection.

DEFINITION

- Robot technology is an applied science that is referred to as a combination of machine tools and computer applications.
- Includes such diverse fields as machine design, control theory, microelectronics, computer programming, artificial intelligence, human factors, and production theory.
GENERAL CHARACTERISTICS

- A SPECIALIZED MACHINE TOOLS WITH A DEGREE OF FLEXIBILITY THAT DISTINGUISHES THEM FROM FIXED-PURPOSE AUTOMATION.

- IT IS ESSENTIALLY A MECHANICAL ARM THAT IS BOLTED TO THE FLOOR, A MACHINE, THE CEILING, OR, IN SOME CASES THE WALL FITTED WITH ITS MECHANICAL HAND, AND TAUGHT TO DO REPETITIVE TASK IN A CONTROLLED, ORDERED ENVIRONMENT.

- ABILITY TO MOVE MECHANICAL ARM TO PERFORM WORK.

- ROBOT INTERFACE WITH THEIR WORK ENVIRONMENT ONCE A MECHANICAL HAND HAS BEEN ATTACHED TO THE ROBOT’S TOOL-MOUNTING PLATE.

DEFINITIONS:

- WORK ENVELOPE: THE SET OF POINTS REPRESENTING THE MAXIMUM EXTENT OR REACH OF THE ROBOT HAND OR WORKING TOOL IN ALL DIRECTIONS.
PAYLOAD: The ability to carry, continuously and satisfactorily, a given maximum weight at a given speed.

VELOCITY: The maximum speed at which the tip of a robot is capable of moving at full extension, expressed in inches or millimeters per second.

CYCLE: Time it takes for the robot to complete one cycle of picking up a given object at a given height, moving it to a given distance, lowering it, releasing it, and returning to the starting point.

ACCURACY: A robot’s ability to position the end effector at a specified point in space upon receiving a control command without previously having attained that position.

REPEATABILITY: The ability of a robot to return consistently to a previously defined and achieved location.

RESOLUTION: The smallest incremental change in position that it make or its control system can measure.

SIZE: The physical size of a robot, which influences its capacity and its capabilities.
BASIC COMPONENTS

THE BASIC COMPONENTS OF AN INDUSTRIAL ROBOT ARE THE

- MANIPULATOR
- THE POWER SUPPLY
- AND THE CONTROLLER.

THE MANIPULATOR, WHICH IS THE ROBOT’S ARM, CONSISTS OF SEGMENTS JOINED TOGETHER WITH AXES CAPABLE OF MOTION IN VARIOUS DIRECTIONS ALLOWING THE ROBOT TO PERFORM WORK.

THE END EFFECTOR WHICH IS A GRIPPER TOOL, A SPECIAL DEVICE, OR Fixture ATTACHED TO THE ROBOT’S ARM, ACTUALLY PERFORMS THE WORK.

POWER SUPPLY PROVIDES AND REGULATES THE ENERGY THAT IS CONVERTED TO MOTION BY THE ROBOT ACTUATOR, AND IT MAY BE EITHER ELECTRIC, PNEUMATIC, OR HYDRAULIC.

THE CONTROLLER INITIATES, TERMINATES, AND COORDINATES THE MOTION OF SEQUENCES OF A ROBOT. ALSO IT ACCEPTS THE NECESSARY INPUTS TO THE ROBOT AND PROVIDES THE OUTPUTS TO INTERFACE WITH THE OUTSIDE WORLD.
Figure 2.3.1 Basic components of an industrial robot
MANIPULATOR

- IS A MECHANICAL UNIT THAT PROVIDES MOTIONS SIMILAR TO THAT OF A HUMAN ARM.

- ITS PRIMARY FUNCTION IS TO PROVIDE THE SPECIFIC MOTIONS THAT WILL ENABLE THE TOOLING AT THE END OF THE ARM TO DO THE REQUIRED WORK.

- A ROBOT MOVEMENT CAN BE DIVIDED INTO TWO GENERAL CATEGORIES: ARM AND BODY (SHOULDER AND ELBOW) MOTIONS AND WRIST MOTIONS.

- THE INDIVIDUAL JOINT MOTIONS ASSOCIATED WITH THESE CATEGORIES ARE REFERRED TO AS DEGREE OF FREEDOM.

- EACH AXIS IS EQUAL TO ONE DEGREE OF FREEDOM. TYPICALLY AN INDUSTRIAL ROBOTS ARE EQUIPPED WITH 4-6 DEGREES OF FREEDOM.
THE WRIST CAN REACH A POINT IN SPACE WITH SPECIFIC ORIENTATION BY ANY OF THREE MOTIONS: A PITCH, OR UP-AND-DOWN-MOTION; A YAW, OR SIDE-TO-SIDE MOTION; AND A ROLL, OR ROTATING MOTION.

THE JOINT LABELED PITCH, YAW, AND ROLL ARE CALLED ORIENTATION AXES.

THE POINTS THAT MANIPULATOR BENDS, SLIDES, OR ROTATES ARE CALLED JOINTS OR POSITION AXES.

MANIPULATION IS CARRIED OUT USING MECHANICAL DEVICES, SUCH AS LINKAGES, GEARS, ACTUATORS, AND FEEDBACK DEVICES.

POSITION AXES ARE CALLED AS WORLD COORDINATES, IS IDENTIFIED AS BEING FIXED LOCATION WITHIN THE MANIPULATOR THAT SERVES AS ABSOLUTE FRAME OF REFERENCE.

THE X-AXIS TRAVEL MOVES THE MANIPULATOR IN AN IN-AND-OUT MOTION.

THE Y-AXIS MOTION CAUSES THE MANIPULATOR TO MOVE SIDE-TO-SIDE.

THE Z-AXIS MOTION CAUSES THE MANIPULATOR TO MOVE IN AND UP-AND-DOWN MOTION.

THE MECHANICAL DESIGN OF A ROBOT MANIPULATOR RELATES DIRECTLY TO ITS WORK ENVELOPE AND MOTION CHARACTERISTICS.
Figure 2.3.5  Parts of a manipulator: The industrial robot manipulator has a body, arm, and wrist. Names match those of the corresponding human parts.
END EFFECTOR

◆ IS THE DEVICE THAT IS MECHANICALLY OPENED AND CLOSED.

◆ ACT AS THE TOOL-MOUNTING PLATE

◆ DEPENDING ON THE TYPE OF OPERATION, CONVENTIONAL END EFFECTORS ARE EQUIPPED WITH VARIOUS DEVICES AND TOOL ATTACHMENTS, AS FOLLOWS:

  - GRIPPERS, HOOKS, SCOOPS, ELECTROMAGNETS, VACUUM CUPS, AND ADHESIVE FINGERS FOR MATERIAL HANDLING.
  - SPRAY GUN FOR PAINTING.
  - ATTACHMENTS FOR SPOT AND ARC WELDING AND ARC CUTTING.
  - POWER TOOLS SUCH AS DRILLS, NUT DRIVERS, AND BURRS.
  - SPECIAL DEVICES AND FIXTURES FOR MACHINING AND ASSEMBLY.
  - MEASURING INSTRUMENTS, SUCH AS DIAL INDICATORS, DEPTH GAUGES, AND THE LIKE.

  Fig. ILLUSTRATES VARIOUS DEVICES AND TOOLS ATTACHED TO THE END EFFECTOR TO PERFORM A VARIETY OF OPERATIONS

END EFFECTORS GENERALLY CUSTOM-MADE TO MEET SPECIAL HANDLING REQUIREMENTS.

MECHANICAL GRIPPERS ARE MOST COMMONLY USED AND ARE EQUIPPED WITH TWO OR MORE FINGERS.

THE SELECTION OF AN APPROPRIATE END EFFECTOR FOR A SPECIFIC APPLICATION DEPENDS UPON FACTORS SUCH AS PAYLOAD, ENVIRONMENT, RELIABILITY, AND COST.
POWER SUPPLY

THE FUNCTION OF THE POWER SUPPLY IS TO PROVIDE AND REGULATE ENERGY THAT IS REQUIRED FOR A ROBOT TO BE OPERATED.

THERE ARE THREE BASIC TYPES OF POWER SUPPLIES:
- ELECTRIC
- HYDRAULIC
- PNEUMATIC

ELECTRICITY IS THE MOST COMMON SOURCE OF POWER AND IS USED EXTENSIVELY WITH INDUSTRIAL ROBOTS.

THE SECOND MOST COMMON USES PNEUMATIC, AND THE LEAST COMMON IS HYDRAULIC POWER.

THE POWER SUPPLY HAS A DIRECT RELATION TO THE PAYLOAD RATING.
CONTROLLER

The controller is a communication and information processing device that initiates, terminates and coordinates the motions and sequences of a robot.

It accepts necessary inputs to the robot and provides the output drive signals to a controlling motor or actuator to correspond with the robot movements and outside world.

Block diagram illustrates the many different parts of robot controller.

The heart of the controller is the computer and its solid-state memory.

The input and output section of a control system must provide a communication interface between the robot controller computer and following parts:

- Feedback sensors
- Production sensors
- Production machine tools
- Teaching device
- Program storage devices, hard copy devices.
THE COMPUTER CONTROLS THE MOTION OF THE ROBOT ARM BY MEANS OF DRIVE SIGNALS THAT PASS THROUGH THE DRIVE INTERFACE TO THE ACTUATORS ON THE ARM.

ROBOTS ARE OFTEN CLASSIFIED UNDER THE THREE MAJOR CATEGORIES, ACCORDING TO THE TYPE OF CONTROL SYSTEM USED:

- NONSERVO - OPEN LOOP SYSTEM
- SERVO - CLOSED LOOP SYSTEM
- SERVO-CONTROLLED - CLOSED LOOP SYSTEMS WITH CONTINUOUSLY CONTROLLED PATH.
Figure 2.3.12a  Robot controller block diagram.
ROBOT ANATOMY

ROBOT ANATOMY IS CONCERNED WITH THE PHYSICAL CONSTRUCTION AND CHARACTERISTICS OF THE BODY, ARM, AND WRIST, WHICH ARE COMPONENTS OF ROBOT MANIPULATOR.

MOVEMENTS BETWEEN THE VARIOUS COMPONENTS OF THE BODY, ARM, AND WRIST ARE PROVIDED BY A SERIES OF JOINTS.

ATTACHED TO THE ROBOT WRIST IS THE END EFFECTOR (OR END-OF-ARM TOOLING) THAT PERFORMS THE WORK.

THE END EFFECTOR IS NOT CONSIDERED A PART OF THE ROBOT’S ANATOMY.

ROBOT CONFIGURATIONS:

1. INDUSTRIAL ROBOTS ARE AVAILABLE IN A WIDE RANGE OF SHAPES, SIZES, SPEEDS, LOAD CAPACITIES, AND OTHER CAPABILITIES.
2. THE VAST MAJORITY OF TODAY’S COMMERCIALLY AVAILABLE ROBOTS POSSESS FIVE DISTINCT DESIGN CONFIGURATIONS:
   A. RECTANGULAR (OR CARTESIAN)
   B. CYLINDRICAL (OR POST-TYPE)
   C. SPHERICAL (OR POLAR)
   D. JOINTED ARM (ARTICULATED OR REVOLUTE)
   E. SCARA (SELECTIVE COMPLIANCE ASSEMBLY ROBOT ARM)
ROBOT GENERATIONS

THE FIVE GENERATIONS OF ROBOT CONTROLLERS AFTER THE HIGH-TECH INCEPTION IN 1960 ARE AS FOLLOWS:

- FIRST GENERATION: REPEATING ROBOTS. THESE WERE GENERALLY PICK AND PLACE ROBOTS, WITH MECHANICAL SEQUENCES DEFINING STOP POINTS.
- SECOND GENERATION: HARDWIRED CONTROLLERS PROVIDED THE FIRST PROGRAMMABLE UNITS.
- THIRD GENERATION: PROGRAMMABLE LOGIC CONTROLLERS (PLC), INTRODUCED IN THE INDUSTRY OVER THIRTEEN YEARS AGO, PROVIDED A MICROPROCESSOR-BASED ROBOTIC CONTROLLER THAT IS EASY TO PROGRAM.
- FOURTH GENERATION: WHEN CONTROL BEYOND THE PLC IS REQUIRED, A MICROCOMPUTER MAY CONTROL THE COMPLETE SYSTEM, INCLUDING OTHER PROGRAMMABLE MACHINERY IN A ROBOT WORKCELL.
- FIFTH GENERATION: ROBOT CONTROLLER WILL INVOLVE COMPLETE ARTIFICIAL INTELLIGENCE (AI), MINIATURIZED SENSORS, AND DECISION-MAKING CAPABILITIES.

AN ARTIFICIAL BIOLOGICAL ROBOT MIGHT PROVIDE THE IMPETUS FOR SIXTH AND HIGHER GENERATIONS OF ROBOTS.
ROBOT SELECTION

ROBOT MUST BE MATCHED PROPERLY BY CAPABILITIES TO TASK REQUIREMENTS.

AN OBJECTIVE APPROACH TO ROBOT SELECTION PROVIDES FEWER RESTRICTIONS IN SYSTEM DESIGN BY ALLOWING FOR THE OPTIMUM SYSTEM DESIGN TO BE ACHIEVED REGARDLESS OF THE SPECIFIC ROBOT NEED.

CRITERIA FOR ROBOT SELECTION:

- TECHNICAL ISSUES:
  - TYPE: NONSERVO, SERVO, SERVO-CONTROLLED
  - WORK ENVELOPE: RECTANGULAR, CYLINDRICAL, SPHERICAL, JOINTED ARM, SCARA
  - PAYLOAD
  - CYCLE TIME
  - REPEATABILITY
  - DRIVE: ELECTRIC, PNEUMATIC, HYDRAULIC, ANY COMBINATION
  - UNIQUE CAPABILITIES

- NON-TECHNICAL ISSUES:
  - COST AND BENEFIT CONSIDERATION
  - COMMONALITY OF EQUIPMENT
  - TRAINING AND MAINTENANCE REQUIREMENTS
  - RELIABILITY
  - SERVICE
  - "SYSTEMS" HELP
  - SAFETY
SUMMARY

◆ ROBOT TECHNOLOGY IS AN APPLIED SCIENCE THAT IS REFERRED TO AS COMBINATION OF MACHINE TOOL FUNDAMENTALS AND COMPUTER APPLICATIONS.

◆ THE BASIC COMPONENTS OF AN INDUSTRIAL ROBOT ARE, MANIPULATOR, END EFFECTOR, POWER SUPPLY AND CONTROL SYSTEM.

◆ ROBOT ANATOMY IS CONCERNED WITH THE PHYSICAL CONSTRUCTION AND OPERATION OF THE MANIPULATOR AND HAS FIVE BASIC CONFIGURATIONS: RECTANGULAR, CYLINDRICAL, SPHERICAL, JOINTED-ARM, AND SCARA.

◆ SO FAR, THERE HAVE BEEN FIVE GENERATIONS OF ROBOT CONTROLLERS, AND WE ARE Merging NOW TO SIXTH, SEVENTH, AND EVEN HIGHER GENERATIONS.
Robots with increasing intelligence, sensory capability, dexterity, and sophisticated control systems have become dominant factor in modern manufacturing.

The three factors that influence the selection of robots in manufacturing are: dynamic properties and performance, economics and safety.