Title: *Foundations of Robotics: Principles, Systems, and Intelligence*

Chapter 1: Introduction to Robotics

Robotics is the interdisciplinary field focused on the design, construction, operation, and use of robots. A robot is a machine—especially one programmable by a computer—capable of carrying out complex tasks automatically.

Robots can be autonomous or semi-autonomous and range from humanoids to industrial arms. Robotics integrates mechanical engineering, electrical engineering, computer science, and artificial intelligence.

Applications include manufacturing, surgery, disaster response, and more.

Chapter 2: Sensors and Actuators

Sensors collect data from the physical environment, while actuators act upon it. Common sensors include cameras, LiDAR, infrared, and ultrasonic sensors.

Actuators include motors, servos, and hydraulic systems. Together, they form the core of robot perception and motion.

The integration of these components allows robots to sense and interact with their surroundings intelligently.

Chapter 3: Robot Control Systems

Control systems manage how a robot responds to inputs and navigates its environment. These systems can be open-loop (no feedback) or closed-loop (with feedback).

Closed-loop control, or feedback control, is more common and uses sensors to adjust the robot's actions in real-time.

Controllers like PID (Proportional-Integral-Derivative) are widely used for precise control of movement and positioning.

Control algorithms are essential for tasks such as path planning, balance, and obstacle avoidance.

Chapter 4: Kinematics and Dynamics

Kinematics involves the study of motion without considering forces, while dynamics includes the effect of forces and torques.

Forward kinematics calculates the position of robot parts given joint parameters, and inverse kinematics finds joint parameters for a desired position.

Understanding these concepts is crucial in robot arm movement, walking robots, and mobile platforms.

Dynamics help simulate realistic movement and are essential for stability and control in physical robots.

Chapter 5: Programming and Simulation

Robots are typically programmed using languages like Python, C++, or Robot Operating System (ROS).

Simulation environments such as Gazebo, V-REP, or Webots allow for testing algorithms before deploying to real hardware.

Programming includes writing behavior scripts, motion sequences, sensor integration, and decision-making logic.

Simulations help optimize performance and reduce errors during real-world deployment.

Chapter 6: Artificial Intelligence in Robotics

AI enhances robot intelligence by enabling perception, decision-making, and learning.

Techniques like machine learning, neural networks, and computer vision allow robots to recognize objects, understand speech, or adapt to new environments.

AI is used in autonomous vehicles, service robots, and collaborative robotics (cobots).

Reinforcement learning and deep learning are key in developing advanced robotic behaviors and autonomy.

Chapter 7: Human-Robot Interaction (HRI)

HRI studies how humans and robots communicate and collaborate effectively.

Interaction methods include speech, gestures, facial recognition, and haptic feedback.

Designing intuitive interfaces ensures safety and usability, especially in service or assistive robots.

Ethics, trust, and acceptance are important factors in successful integration of robots into daily life.