

Lec1&2

1. Multiple Choice Questions (MCQs):**

1. **What is the primary goal of robotics according to the PDF?**

- a) To design machines that require constant human intervention.
- b) To create intelligent machines that assist humans in various tasks.
- c) To develop sensors only.

Answer: (b) - (Page 4).

2. **Which of these robots is considered "fixed base" according to the PDF?

- a) A self-driving car.
- b) A robotic arm in a factory.
- c) A home cleaning robot.

Answer: (b) - (Page 19).

3. **What type of joint allows movement in only one rotational axis?**

- a) Prismatic joint.
- b) Revolute joint.
- c) Spherical joint.

Answer: (b) - (Page 51).

4. **Which sensor would a robot use to detect toxic gas?**

- a) Accelerometer.
- b) Flexiforce sensor.
- c) Chemical sensor (not explicitly listed, but implied under robot sensors' broader function).

Answer: (c) - (Implied from Page 22: "measure... presence of toxic gas").

5. **What is the key difference between open-loop and closed-loop control?**

- a) Open-loop uses feedback; closed-loop does not.

- b) Closed-loop uses feedback; open-loop does not.
- c) Both systems operate identically.

****Answer: (b) - (Page 52).****

2. True/False Questions:

1. ****All machines are robots, but not all robots are machines.****

****Answer: False**** (Page 8: "All Robots Are Machines, But Not All Machines Are Robots").

2. ****ROS is a proprietary (closed-source) operating system for robots.****

****Answer: False**** (Page 63: "open-source").

3. ****A robotic arm with 6 DOF can theoretically reach any position and orientation in 3D space.****

****Answer: True**** (Page 60-62: DOF discussion).

3. Short Answer Questions:**

1. **List the four main components of a robot as mentioned in the PDF.**

****Answer:**** Sensors, Power conversion unit, Controller, Actuators (Page 18).

2. **What is the purpose of a "force sensor" in robotics? Give one application.**

****Answer:**** Measures force during tasks; e.g., precise part insertion or robotic surgery (Page 25).

3. **Define "repeatability" and "accuracy" in robotics.**

****Answer:****

- ****Repeatability:**** Positional deviation from the average displacement.

- ****Accuracy:**** Ability to reach a desired target point (Page 42).

4. Diagram-Based Question:**

Refer to the closed-loop control diagram (Page 55).

- **What is the role of the "Feedback signal"?**

Answer: It compares the estimated pose (from sensors) with the desired pose to compute error (ε) for correction.

5. Advanced Questions (Still PDF-Based but Deeper):**

1. **Explain how the "Piezoelectric Effect" is used in an accelerometer (refer to Page 22).**

Answer: Piezoelectric materials generate voltage when deformed; accelerometers use this to measure acceleration-induced deformation.

2. **Why might a manufacturing robot use a cylindrical joint (Page 51)? Provide an example.**

****Answer:**** Combines rotational + linear motion; e.g., a robotic drill needing both spin and vertical movement.

3. ****How does the PDF define "teleoperation"? What is its key challenge in space missions?****

****Answer:**** Human remotely controls a robot; challenge: time delay (e.g., 140 mins on Mars vs. 1 min on Earth) (Page 57).

Here are the answers organized by question type:

1. Definition Questions Answers:

1. ****Robotics****: A branch of engineering and computer science involving conception, design, manufacture and operation of robots to create intelligent machines that assist humans (Page 4)

2. ****Robot vs Machine****:

Robots operate independently and adapt; machines perform fixed tasks needing human intervention (Page 8)

3. **Repeatability**: Positional deviation from average displacement over repeated movements (Page 42)

4. **DOF**: Number of independent parameters defining a robot's configuration (Page 59)

5. **Sensor fusion**: Combining data from multiple sensors for comprehensive understanding (Implied Page 3)

6. **Open-loop control**: Executes pre-programmed commands without feedback (Page 52)

7. **Revolute joint**: Allows rotation about single axis (Page 51)

8. **ROS**: Robot Operating System - open-source middleware for robotics programming (Page 63)

9. **Teleoperation**: Human remote control of robots with master-slave relationship (Page 57)

10. **End effectors**: Tools/devices at robot's working arm tip (Implied Page 9)

2. MCQ Answers:

1. c) Operating system
2. c) Cylindrical
3. c) Proximity sensor
4. b) Open-source middleware
5. b) Robotic arm with force feedback

3. Comparison Answers:

1. **Open vs Closed-loop**:

- Open: No feedback, deterministic environment
- Closed: Uses sensor feedback for error correction

(Page 52,55)

2. **Holonomic vs Non-holonomic**:

- Holonomic: Controllable DOFs = Total DOFs
- Non-holonomic: Controllable DOFs < Total DOFs

(Page 62)

3. **Fixed vs Mobile robots**:

- Fixed: Stationary base (e.g., factory arms)
- Mobile: Wheeled/legged platforms (Page 19-20)

4. **Repeatability vs Accuracy**:

- Repeatability: Consistency to reach same point
- Accuracy: Precision to reach target point (Page 42)

5. **Manipulator vs Mobile**:

- Manipulator: Fixed, precise part handling
- Mobile: Navigation in environments (Page 11,14)

4. Application Answers:

1. **Vision sensors**: Enable random bin picking by 3D object recognition (Page 23)
2. **Force sensors**: Provide feedback for precise tissue handling in surgery (Page 25)

3. **Spherical joint**: Allows multi-directional movement for complex orientations (Page 51)
4. **Piezoelectric effect**: Generates voltage when deformed to measure acceleration (Page 22)
5. **Closed-loop in AVs**: Corrects wheel slippage using sensor feedback (Page 55)

5. Diagram Answers:

1. **Robotic system**: Sensors → Controller → Actuators → Manipulator (Page 18)
2. **Feedback loop**: Compares desired vs actual pose to compute error (Page 55)
3. **DOF diagram**: $6 \text{ DOF} = 3 \text{ positional} + 3 \text{ rotational}$ (Page 60)
4. **Joint mechanism**: Labels for links, joints, actuators (Page 21)
5. **ROS architecture**: Nodes → Topics → Services (Page 63)

6. Calculation Answers:

1. **Total DOF**: $3R + 1P = 4$ DOF (Page 51 table)
2. **± 0.1 mm repeatability**: 99.7% of positions within 0.3mm variation (Page 42)
3. **2-link workspace**: Circular area with radius = sum of link lengths
4. **Sensor coverage**: Ultrasonic (15cm-3m) + IR (5-20cm) for layered detection (Page 26)
5. **Control frequency**: $\geq 10 \times$ task dynamics (e.g., 100Hz for 10Hz motion)

7. Historical/Conceptual Answers:

1. **Evolution**: From industrial arms \rightarrow autonomous mobile robots \rightarrow AI-integrated systems (Page 16)
2. **IoT impact**: Enables big data processing for machine learning (Page 6)
3. **Social implications**: Job displacement vs. hazardous task reduction (Page 41,44)

4. **Advantages**: Precision, 24/7 operation;
Disadvantages: High costs, unemployment (Page 43-45)

5. **Future trends**: More autonomous, collaborative robots (cobots), soft robotics (Implied)

8. Case Study Answers:

1. **Mars rover sensors**: Vision (navigation), force (soil sampling), tilt (terrain stability) (Page 14,22,27)

2. **Nuclear robot**: Radiation-hardened manipulator with force feedback (Page 33)

3. **Warehouse picker**: 6DOF arm with spherical wrist + vacuum gripper (Page 11,51)

4. **Drone control**: PID for stabilization + GPS waypoint navigation (Implied)

5. **Service robot ROS**: MoveIt for motion, OpenCV for vision, TF for mapping (Page 63)

Answer Key Features:

- Page references for verification
- Combines verbatim PDF content with applied reasoning
- Covers theoretical and practical aspects
- Scales from basic recall to system design

Here are 30 additional multiple-choice questions (MCQs) covering all key topics from the PDF, with increasing difficulty:

Basic Recall Questions (10)

1. What is the primary purpose of robotics according to the PDF?

- a) To replace all human jobs
- b) To create intelligent machines that assist humans
- c) To develop only industrial machines
- d) To reduce computer science applications

Answer: b) (Page 4)

2. Which component is NOT part of a robot's basic structure?

- a) Sensor
- b) Actuator
- c) Database
- d) Controller

****Answer: c) (Page 18)****

3. What type of joint allows only rotational movement?

- a) Prismatic
- b) Revolute
- c) Spherical
- d) Planar

****Answer: b) (Page 51)****

4. ROS stands for:

- a) Robot Operating Software
- b) Robotic Output System

- c) Robot Operating System
- d) Remote Operating Sensor

****Answer: c) (Page 63)****

5. Which sensor measures force in robotics?

- a) Accelerometer
- b) Flexiforce sensor
- c) Proximity sensor
- d) Tilt sensor

****Answer: b) (Page 25)****

****Intermediate Application Questions (10)****

6. A robotic arm that can reach any position in 3D space needs at least:

- a) 3 DOF
- b) 6 DOF

c) 9 DOF

d) 12 DOF

****Answer: b) (Page 60)****

7. Closed-loop control is essential for:

a) Traffic lights

b) Robotic surgery

c) Conveyor belts

d) Washing machines

****Answer: b) (Page 55)****

8. Which robot type would use a cylindrical joint?

a) Self-driving car

b) Drone

c) Industrial drill arm

d) Humanoid robot

****Answer: c) (Page 51)****

9. The piezoelectric effect is used in:

- a) DC motors
- b) Accelerometers
- c) Hydraulic actuators
- d) Vision sensors

****Answer: b) (Page 22)****

10. Teleoperation becomes challenging when:

- a) Tasks are repetitive
- b) There's transmission delay
- c) Robots have 6 DOF
- d) Sensors are infrared-based

****Answer: b) (Page 57)****

****Advanced Synthesis Questions (10)****

11. A robot with 4 revolute joints and 2 prismatic joints has:

- a) 4 DOF
- b) 6 DOF
- c) 8 DOF
- d) 12 DOF

****Answer: b) (Page 51 table)****

12. Which combination would a Mars rover need?

- a) Vision + force + tilt sensors
- b) Only proximity sensors
- c) Just hydraulic actuators
- d) Open-loop control only

****Answer: a) (Pages 22,25,27,14)****

13. If a robot has good repeatability but poor accuracy, it:

- a) Reaches different points inconsistently

b) Consistently misses the target by the same margin

c) Cannot store programs

d) Overheats frequently

****Answer: b) (Page 42 diagram)****

14. ROS is critical for:

a) Hardware abstraction only

b) Combining perception, planning, and control

c) Replacing all sensors

d) Making robots humanoid

****Answer: b) (Page 63)****

15. A non-holonomic robot:

a) Has controllable DOFs = Total DOFs

b) Cannot move backward

c) Has fewer controllable DOFs than total DOFs

d) Only operates in factories

****Answer: c) (Page 62)****

**Expert-Level Scenario Questions (10)**

16. For precise part insertion, a robot would need:

- a) Only vision sensors
- b) Force sensors with closed-loop control
- c) Open-loop programming
- d) 2 DOF

****Answer: b) (Page 25,55)****

17. Which is TRUE about robotic actuators?

- a) Pneumatic cylinders are best for precise surgery
- b) DC motors convert electrical to mechanical energy
- c) Muscle wires are used for heavy lifting
- d) Hydraulic motors are silent

****Answer: b) (Page 28-29)****

18. A robot with 7 controllable DOFs but only 6 needed for its task is:

- a) Non-holonomic
- b) Redundant
- c) Underactuated
- d) A machine, not a robot

****Answer: b) (Page 62)****

19. In the nuclear plant decontamination example (Page 33), the robot primarily:

- a) Reduces human risk
- b) Increases production speed
- c) Lowers costs
- d) Entertains workers

****Answer: a)****

20. Sensor fusion helps autonomous vehicles by:

- a) Combining camera, LiDAR, and ultrasonic data
- b) Using only one sensor type
- c) Eliminating controllers
- d) Reducing DOF

****Answer: a) (Implied Page 6)****

****Tricky Distractor Questions (10)****

21. Which is NOT a robot type mentioned?

- a) Legged robot
- b) Wheeled robot
- c) Flying broomstick
- d) Autonomous underwater vehicle

****Answer: c) (Pages 12-14)****

22. A key limitation of industrial robots is:

- a) Better assembly than humans
- b) Unlimited work volume
- c) Closed control architectures
- d) Low accuracy

****Answer: c) (Page 45)****

23. The Predator B is an example of a:

- a) Surgical robot
- b) Military drone
- c) Home vacuum robot
- d) Mars rover

****Answer: b) (Page 39)****

24. Proprioceptive sensing refers to:

- a) External environment data
- b) The robot's internal state
- c) Only vision feedback
- d) Human operator inputs

****Answer: b) (Page 52)****

25. A robotic dishwasher would be classified as:

- a) A true robot (autonomous)
- b) A machine (fixed function)
- c) A redundant system
- d) An underactuated device

****Answer: b) (Page 8 logic)****
