

Question 1: A mobile robot must reliably detect obstacles in dim light and through dust. Which sensing option is best for coarse distance measurement in these conditions?

- a) Camera with visible-light processing
- b) Ultrasonic sensor
- c) Ambient light sensor
- d) Temperature sensor

Question 2: You're prototyping a gearbox housing that must be tested for fit quickly as a single piece — which prototyping method gives the fastest low-cost for 3D single piece parts iteration?

- a) Injection moulding
- b) 3D printing (FDM)
- c) Laser cutting flat plates
- d) Die casting

Question 3: A student builds a simple circuit: a 9 V battery and three resistors in series ($2\ \Omega$, $4\ \Omega$, $4\ \Omega$). Which statement best describes the current through each resistor?

- a) Current splits according to resistor size
- b) Current is zero in the smallest resistor only
- c) Current differs in each resistor proportional to resistance
- d) Current is the same through all resistors

Question 4: In a controlled experiment, the p-value returned is 0.03. Which is the most accurate interpretation of this p-value?

- a) The alternative hypothesis is true with probability 0.03
- b) Given the null is true, the probability of getting data as extreme as observed is 0.03
- c) The effect size is 3%
- d) This proves the null hypothesis

Question 5: Which of the following best describes a disruptive technology example from recent decades?

- a) A smartphone that combined telephony, computing, and internet access
- b) A slightly faster model of a gasoline sedan with same features
- c) A seasonal new flavour of a soft drink

d) A higher-capacity battery of the same form factor

Question 6: A city plans to reduce urban heat island effect. Which intervention will most directly lower surface temperatures?

- a) Painting roofs black to retain heat
- b) Installing green roofs and increasing tree canopy
- c) Replacing grass with asphalt for maintenance ease
- d) Removing reflective surfaces

Question 7: In precision pick-and-place robotics, which specification describes how consistently an actuator returns to the same position under identical conditions?

- a) Torque
- b) Repeatability
- c) Maximum speed
- d) Payload

Question 8: You need a loop that runs until a sensor reports a condition is met, but the number of iterations is unknown. Which programming construct is most appropriate?

- a) For loop with fixed count
- b) While loop that checks the condition each iteration
- c) Switch-case construct
- d) Inline comment

Question 9: A prototype requires an internal overhanging cavity inaccessible from outside; which prototyping approach best creates such internal geometry with minimal assembly?

- a) CNC milling a solid block only
- b) 3D printing with soluble supports
- c) Laser cutting sheet and gluing layers only
- d) Hand carving from foam only

Question 10: A long straight current-carrying wire produces a magnetic field around it. Which rule helps determine the field direction?

- a) Right-hand rule
- b) Bernoulli's principle
- c) Fleming's left-hand rule for motors
- d) Kirchhoff's current law

Question 11: In experimental design, why include a control group?

- a) To provide a reference that isolates the effect of the variable under study
- b) To double the number of participants by default
- c) To bias the study toward expected results
- d) To reduce variability artificially

Question 12: A start-up measures how fast users adopt their app during launch. Which metric best captures adoption speed?

- a) Mean time to first use and daily active user growth (market penetration over time)
- b) Device battery consumption
- c) Average colour palette preference
- d) Unit weight of phone cases

Question 13: Which is a textbook example of non-point source pollution?

- a) Runoff of fertilizer from many agricultural fields after rain
- b) Direct pipe discharge from a single factory
- c) A single sewage outfall into a river
- d) An oil leak from a specific tanker

Question 14: Which control algorithm component reduces steady-state error in a control system?

- a) Proportional term only
- b) Integral term
- c) Derivative term only
- d) Feed-forward with no feedback

Question 15: During early-stage design, an FMEA (Failure Mode and Effects Analysis) is used primarily to:

- a) Identify possible ways the design could fail and prioritize mitigations
- b) Increase final production cost estimates only
- c) Replace prototyping entirely
- d) Generate marketing slogans

Question 16: Kirchhoff's Voltage Law (KVL) states that the algebraic sum of voltages around any closed loop equals:

- a) The battery voltage only
- b) Zero
- c) The total current multiplied by resistance in the loop
- d) The highest single voltage drop

Question 17: In a double-blind clinical trial both the participants and the researchers interacting with them do not know who received the treatment. The main benefit is:

- a) Reduction of both subject and experimenter bias
- b) Faster recruitment of participants
- c) Reduced statistical power
- d) Saving on data collection costs

Question 18: Moore's Law historically described a trend in:

- a) Transistor density roughly doubling every ~18–24 months
- b) Annual doubling of battery energy density
- c) Growth of global internet bandwidth by fixed amount each year
- d) Screen pixel size reduction

Question 19: For municipal wastewater biological treatment, which process is widely used to reduce organic load?

- a) Activated sludge process
- b) Direct chlorination only
- c) High-temperature incineration of raw sewage
- d) Freezing and storage

Question 20: For precise small-angle moves in a robotic joint where you need step resolution and no feedback loop, which actuator is commonly chosen?

- a) Stepper motor
- b) Hydraulic cylinder only
- c) Solenoid for continuous rotation
- d) Gas turbine

Question 21: What is the average-case time complexity of binary search on a sorted array of n elements?

- a) $O(n)$
- b) $O(\log n)$
- c) $O(n \log n)$
- d) $O(n^2)$

Question 22: Which commonly used 3D printing filament is derived from plant starch and considered more biodegradable than petroleum-based filaments?

- a) PLA (polylactic acid) — (more biodegradable under industrial composting conditions)
- b) ABS (acrylonitrile butadiene styrene)
- c) PETG
- d) Nylon

Question 23: The SI unit of magnetic flux is the:

- a) Weber (Wb)
- b) Tesla (T)
- c) Henry (H)
- d) Coulomb (C)

Question 24: In human-subject research, obtaining informed consent primarily protects which ethical principle?

- a) Respect for persons
- b) Maximizing statistical significance
- c) Reducing cost of the study
- d) Ensuring results match hypotheses

Question 25: Which description best fits for blockchain technology?

- a) A distributed ledger that records transactions in linked blocks and is tamper-evident
- b) A new kind of CPU architecture for faster floating-point operations
- c) A method for increasing battery capacity by 50%
- d) A camera sensor enhancement algorithm

Question 26: A team wants to minimize a robot arm's power draw while retaining speed.

Which design trade-off is most relevant?

- a) Lowering motor torque or using gear reductions to allow smaller motors
- b) Increasing idling current to keep motors warm
- c) Replacing motors with heavier actuators with same power
- d) Increasing motor supply voltage without considering gearing

Question 27: In describing magnetic field lines, which statement is true?

- a) Field lines emerge from north pole and enter south pole outside a magnet
- b) Magnetic field lines start and end on charges like electric field lines
- c) Field lines cross where field is strongest
- d) Magnetic field lines do not form closed loops

Question 28: A research design uses randomization, blocking, and replication.

Which issue does blocking primarily address?

- a) Reducing variability due to known nuisance factors by grouping similar experimental units
- b) Increasing total sample size beyond budget
- c) Preventing data entry errors automatically
- d) Ensuring participants cannot drop out

Question 29: For a compact, low-cost distance sensing around a small mobile robot (short range, ~2 m) with low processing overhead, which is a practical choice?

- a) LIDAR only (expensive for small robots)
- b) Infrared proximity sensor (IR)
- c) MRI scanner
- d) Gamma-ray sensor

Question 30: A material selection decision: you need a light structural prototype that's easy to machine for testing load-bearing behavior. Which is best?

- a) Polycarbonate printed with low infill only
- b) Aluminium block machined with CNC for realistic stiffness
- c) Wax models only
- d) Cardboard glued layers

Question 31: Which of the following best represents scientific reproducibility?

- a) Independent researchers can obtain similar results using the same methods and data
- b) The same researcher obtains different results every trial
- c) Hiding raw data while publishing conclusions
- d) Changing methods slightly each time without documentation

Question 32: An innovation team measures Minimum Viable Product (MVP) success by validated learning. Which is the core idea behind the MVP?

- a) Build the simplest product to test key hypotheses and learn from users quickly
- b) Build the full feature list before any user testing
- c) Build only to impress investors with flashy visuals
- d) Avoid user feedback to speed development

Question 33: A storm causes diffuse runoff carrying fertilizers into a lake, causing algal blooms. What mitigation at watershed scale helps most?

- a) Construct riparian buffer strips and retention ponds to reduce nutrient runoff
- b) Pave more surfaces to speed water flow to the lake
- c) Remove wetlands next to the lake
- d) Apply extra fertilizer to counteract loss

Question 34: A robot control loop uses PID. You observe oscillation around set point that grows slowly. Which parameter change is most likely to help reduce oscillation?

- a) Increase integral gain significantly
- b) Increase derivative gain (to dampen rate of change)
- c) Remove proportional term completely
- d) Increase set point suddenly

Question 35: In programming, to avoid race conditions when multiple tasks access shared memory concurrently, which technique is appropriate?

- a) Mutex/lock around the shared resource
- b) Always busy-wait without locks
- c) Let tasks write simultaneously for speed
- d) Use magic constants

Question 36: A prototype electronic sensor package will be field-tested for months in humid conditions. Which material/property is most important for enclosure selection?

- a) Corrosion resistance and IP (ingress protection) rating
- b) Bright colour for marketing photos only
- c) Maximum density for weight
- d) Lowest cost without considering environment

Question 37: Which statement about magnetic materials is correct?

- a) Ferromagnetic materials (like iron) can retain magnetization due to domain alignment
- b) All materials are diamagnetic only
- c) Paramagnetism means strong permanent magnet behaviour
- d) Superconductors are magnetic at room temperature

Question 38: A good experimental hypothesis should be:

- a) Falsifiable, specific, and testable using measurable variables
- b) Vague and untestable to cover more cases
- c) Designed to guarantee positive outcomes
- d) Based solely on opinion without variables

Question 39: Which is an example of an incremental innovation (not disruptive)?

- a) Slightly improved lens sharpness in the next phone model
- b) Invention of the first smartphone combining multiple functions
- c) Creation of the World Wide Web from scratch
- d) The first mass-produced internal combustion engine

Question 40: An urban planner wants to reduce stormwater runoff volume. Which Low Impact Development (LID) measure is most effective?

- a) Increased impervious pavements everywhere
- b) Permeable pavements and rain gardens to increase infiltration
- c) Eliminating green spaces for parking lots
- d) Directing all runoff into combined sewers without treatment

Question 41: For obstacle avoidance in dynamic environments where objects move unpredictably, which strategy is more robust?

- a) Rely only on preplanned trajectories in open-loop mode
- b) Combine real-time sensor feedback with reactive motion planning
- c) Use very slow constant motion ignoring sensors
- d) Run sensors only during initialization

Question 42: Which data structure gives average $O(1)$ expected-time for insert, delete, and lookup (amortized) for unordered keys?

- a) Linked list
- b) Hash table (hash map)
- c) Binary search tree always balanced without rotations
- d) Single array with linear search

Question 43: A cantilever beam prototype is failing at the mount due to stress concentration. Which design change most directly reduces peak stress?

- a) Add a fillet (rounded transition) at the mount and increase cross-section near support
- b) Sharpen corners to reduce material usage
- c) Add decorative holes at the mount to reduce weight
- d) Paint the mount to disguise cracks

Question 44: A lab keeps getting different results when repeating measurements of the same sample. Which practice will most help diagnose the problem?

- a) Perform calibration checks, quantify measurement uncertainty, and run replicates
- b) Stop repeating and report the first result only
- c) Increase the sample heating arbitrarily
- d) Only change personnel handling the samples

Question 45: Which business model innovation pairs a low-cost product with a recurring revenue service and often disrupts incumbents?

- a) Hardware minimum with subscription-based services (razor-and-blade / SaaS model)
- b) Selling lifetime-limited warranty only once
- c) Charging only for physical manuals shipped yearly
- d) Removing customer support to cut costs

Question 46: Environmental engineering: Which process converts organic municipal waste into methane-rich biogas?

- a) Anaerobic digestion in a controlled digester
- b) Direct aerobic composting only
- c) Burning raw waste in open pits
- d) Burying without containment

Question 47: A feedback sensor providing noisy readings causes jitter in actuator output. A simple practical remedy is:

- a) Apply a low-pass filter or smoothing to the sensor signal before control decisions
- b) Increase controller gain to amplify noise deliberately
- c) Remove the sensor entirely
- d) Replace sensor readings with random values

Question 48: Which sorting algorithm has average-case time complexity $O(n \log n)$ and is commonly used in practice?

- a) Bubble sort
- b) Quick sort (with good pivot strategy)
- c) Selection sort
- d) Linear search

Question 49: A student measures magnetic field and sees it drop with distance. For a dipole-like magnet, the field magnitude falls roughly as:

- a) $1/r$
- b) $1/r^2$
- c) $1/r^3$
- d) Exponentially with r

Question 50: When a measured difference between groups is statistically significant but effect size is tiny, the responsible interpretation is:

- a) The difference may not be practically important despite statistical significance
- b) The result must be universally important in all contexts
- c) Small effect size means data were measured incorrectly always
- d) Statistical significance guarantees high practical impact

Question 51: You must prototype a sealed sensor that must be lightweight and easily iterated. Which enclosure manufacturing method balances speed and fidelity?

- a) 3D printing the enclosure in PETG/ABS then using a gasket for sealing
- b) Full die cast tooling for the first revision only
- c) Machining titanium blocks for every trial
- d) Gluing thin cardboard sheets

Question 52: Which factor most strongly influences whether a new technology spreads quickly among users?

- a) Relative advantage and perceived usefulness to early adopters
- b) Random chance without user perception
- c) Only the colour scheme of the product
- d) Marketing slogans with no performance claims

Question 53: Environmental engineering: Which water treatment step primarily removes suspended solids?

- a) Sedimentation and coagulation/flocculation
- b) Chlorination for disinfection only
- c) pH adjustment without settling
- d) Aeration for oxygen only

Question 54: A mobile robot needs to localize (know its position) in a known map; which technique fuses odometry with sensor observations to correct drift?

- a) Pure dead-reckoning only
- b) Sensor fusion algorithms like Extended Kalman Filter (EKF) or Particle Filter for SLAM/localization
- c) Only using a stopwatch and manual calculation
- d) Removing map data to avoid complexity

Question 55: Which is a key advantage of modular code with clearly defined interfaces?

- a) Easier testing, parallel development, and reusability
- b) Making debugging impossible
- c) Increasing coupling between components
- d) Removing need for documentation always

Question 56: A magnetized ferromagnetic core shows hysteresis in its B-H curve. What is one engineering implication?

- a) Some magnetic energy is lost as heat during each magnetization cycle (hysteresis loss)
- b) Hysteresis makes materials perfect energy conductors with no loss
- c) Hysteresis eliminates need for current in coils
- d) The core will become superconducting at room temperature

Question 57: A paper's authors hide outliers that don't fit the hypothesis. What is the correct scientific response?

- a) Reanalyse including outliers with transparent reporting and justify any exclusions
- b) Always remove outliers without note to improve p-values
- c) Modify the hypothesis to match the excluded data only
- d) Publish only graphs without data tables

Question 58: A prototype solar-powered sensor must operate off-grid. Which system-level design choice gives best reliability through variable sunlight?

- a) Battery energy storage sized for worst-case low-sun periods plus MPPT (maximum power point tracking) for panels
- b) No battery and rely on cloudy-day luck only
- c) Oversize the sensor with no storage consideration
- d) Use incandescent bulbs instead of solar

Question 59: In an electromagnetic induction experiment, increasing the rate of change of magnetic flux through a coil increases the induced emf according to Faraday's law. Which option best expresses this relation qualitatively?

- a) Induced emf is proportional to the negative rate of change of magnetic flux ($-\frac{d\Phi}{dt}$)
- b) Induced emf is independent of flux change rate
- c) Induced emf equals flux squared
- d) Induced emf equals flux times resistance only

Question 60: To make a handheld device both very thin and robust to drops, which combined approach best balances the trade-offs?

- a) Use high-strength lightweight materials, add internal shock mounts, and design energy-absorbing geometry
- b) Make device thinner by removing internal supports and reducing battery capacity only
- c) Focus only on thinness even if device cracks on first drop
- d) Make an overly heavy metallic device to disregard weight constraints

ROUGH WORK

(NOT TO BE EVALUATED)

DATE

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