Question 1: A mobile robot uses wheel encoders to estimate distance travelled but drifts over time. Which most directly improves odometry accuracy?
a) Increasing motor voltage only
b) Fuse encoder data with an inertial measurement unit (IMU) using sensor fusion
c) Use larger wheels without other changes
d) Reduce wheel diameter slightly

Question 2: In prototyping, a design team chooses a high-fidelity 3D print for final validation. Which primary risk remains if they skip functional testing?
a) Visual appearance mismatch only
b) Mechanical performance under load and real-world interfaces may fail despite good appearance
c) Printing time increases unexpectedly
d) Material colour is slightly off

Question 3: A long straight wire carries current I. Which expression gives the magnetic field magnitude at perpendicular distance r from the wire (μ_0 = permeability)?
a) B=μ0I2πrB = \dfrac{\mu_0 I}{2\pi r}B=2πrμ0I
b) B=μ0Ir2πB = \dfrac{\mu_0 I r}{2\pi}B=2πμ0Ir
c) B=2πrμ0IB = \dfrac{2\pi r}{\mu_0 I}B=μ0I2πr
d) B=μ0Iπr2B = \dfrac{\mu_0 I}{\pi r^2}B=πr2μ0I

Question 4: In experimental design, randomization of subjects primarily protects against:
a) Systematic bias due to confounders by balancing them across groups
b) Measurement instrument calibration errors only
c) Small sample size problems automatically
d) Typographical errors in data

Question 5: A path-planning algorithm returns shortest path times but occasionally fails in dynamic obstacle fields. Which improvement is most relevant?
a) Use a static precomputed path only
b) Integrate dynamic replanning and local obstacle avoidance
c) Increase map resolution without runtime updates
d) Reduce robot speed permanently

Question 6: A solar farm uses DC combiner boxes that overheat. Which engineering design change most directly reduces overheating risk?
a) Add more panels in series per string
b) Improve ventilation/heat sinking and lower current per string by reconfiguring strings
c) Paint the combiner box a darker colour
d) Increase DC voltage without insulation changes

Question 7: Two capacitors 4 μF and 6 μF are connected in series and charged to total voltage 100 V. What is the voltage across the 4 μF capacitor?
a) 40 V
b) 60 V
c) 100 V
d) 25 V

Question 8: A researcher reports p = 0.03 for a new drug effect. Which statement best expresses correct scientific caution?
a) The result is statistically significant at conventional levels, but effect size, replication, and study quality must be evaluated before strong claims.
b) The hypothesis is proven true forever.
c) $p < 0.05$ implies clinical importance automatically.
d) Sample size is irrelevant once $p < 0.05$.

Question 9: An innovation team wants to reduce latency for an IoT sensor network. Which change most likely reduces end-to-end latency?
a) Batch readings and send once per day only
b) Move processing closer to the edge (edge computing) and use lightweight protocols
c) Increase payload size of each message
d) Add extra hops in the network intentionally

Question 10: For sustainable stormwater management, which practice most reduces peak runoff from an urban site?
a) Replace pervious surfaces with concrete
b) Use green infrastructure: infiltration basins, permeable pavements, and rain gardens
c) Increase roof area with no drainage changes
d) Use larger gutters only

Question 11: A robot arm uses PID control to hold position. Which tuning change primarily reduces steady-state error?
a) Increase derivative gain (D) only
b) Increase integral gain (I) carefully to reduce steady-state error, monitoring for overshoot
c) Remove integral term entirely
d) Reduce sampling frequency drastically

Question 12: When prototyping an electronic PCB, which step most reduces chance of manufacturing error?
a) Skip DRC and CAM checks to save time
b) Run design-rule checks (DRC), check footprints, and create detailed fabrication files (Gerbers) for the manufacturer
c) Change pin names after fabrication request
d) Use ambiguous silk-screen labels

Question 13: A straight conductor of length L moves at velocity v perpendicular to a uniform magnetic field B. The induced emf between its ends is:
a) $\varepsilon = BLv$
b) $\varepsilon = \frac{BL}{v}$
c) $\varepsilon = \frac{v}{BL}$
d) $\varepsilon = B + L + v$

Question 14: You design an experiment with two groups but lose random assignment midway. Best corrective action?
a) Stop and restart the trial implementing proper randomization or use preplanned statistical adjustments and clearly report the deviation
b) Continue without reporting
c) Change endpoints to guarantee favourable results
d) Replace data with simulated numbers

Question 15: In a multi-threaded control program for a robot, a race condition caused sporadic errors. Which approach most directly prevents this class of faults?
a) Use appropriate synchronization (mutexes/semaphores) or adopt lock-free algorithms where safe
b) Increase thread priority of all threads equally
c) Remove all mutexes and hope for the best
d) Add random delays in all threads

Question 16: A prototype drone shows resonance at a motor frequency causing vibration. Which design fix is most appropriate?
a) Move payload to unspecified locations randomly
b) Change propeller-motor combination or add vibration isolation/damping to shift resonance away from operating frequency
c) Paint drone to a different colour
d) Increase battery capacity only

Question 17: Two resistors 10 Ω and 20 Ω are connected in parallel across a 12 V battery. What is total current drawn from battery?
a) 1.2 A
b) 1.8 A
c) 3.6 A
d) 2.4 A

Question 18: In planning a field experiment, blocking is used to:
a) Increase random error deliberately
b) Group similar experimental units to reduce within-group variance and isolate treatment effects
c) Replace randomization entirely
d) Hide data from reviewers

Question 19: A start-up proposes using perovskite solar cells for low-cost panels but lifetime is uncertain. What is the best immediate R&D priority?
a) Scale up mass production before stability tests
b) Evaluate degradation under accelerated aging tests and develop encapsulation strategies
c) Ignore lifetime, market aggressively
d) Only improve colour appearance

Question 20: A mobile robot's LiDAR occasionally returns outlier points (spurious reflections). Which software approach best reduces mapping errors?
a) Accept all points — they balance out
b) Implement statistical outlier rejection and temporal filtering (integrate multiple scans) before mapping
c) Increase sensor scan rate only
d) Replace LiDAR with random noise generator

Question 21: For an RC circuit with R = 1 kΩ and C = 1 μF, what is the approximate time constant τ?
a) 1 s
b) 10^{-2} s
c) 1 ms
d) 1000 s

Question 22: In a usability test of a prototype device, one participant struggles because of poor labelling. Which immediate refinement yields the best usability improvement?
a) Add clearer labelling and simple onboarding instructions, then re-test with diverse users
b) Change internal code style only
c) Increase device weight to feel solid
d) Remove labels entirely

Question 23: A coil of N turns with area A is rotated in uniform B; maximum induced emf is proportional to:
a) $NA\omega B$ (where ω is angular speed)
b) $N + A + \omega + B$
c) $NA/(B\omega)$
d) $B/(NA\omega)$

Question 24: Which research practice best reduces confirmation bias in data interpretation?
a) Pre-register hypotheses, define analysis plan, and consider blind analysis where feasible
b) Only analyse data that fits expectations
c) Change hypotheses to fit observed data post hoc without note
d) Hide negative results

Question 25: In robotic grasping, a parallel-jaw gripper struggles with thin flat parts. Which design modification most improves reliability?
a) Use suction or add soft conformable fingertips to increase contact area and adapt to thin profiles
b) Make jaws thinner but rigid only
c) Increase gripping speed only
d) Remove sensors entirely

Question 26: An engineering design review found the material selection had insufficient safety margin. Best next step?
a) Recompute loads, factor in uncertainty, and choose a material or geometry that increases factor of safety per requirements
b) Ignore review and continue
c) Reduce expected loads on paper without evidence
d) Delay testing indefinitely

Question 27: Two identical capacitors charged to V and then connected positive to positive — what happens to net stored energy?
a) Total energy decreases due to redistribution and possible dissipation
b) Energy increases spontaneously
c) Energy remains exactly the same stored in capacitors without losses always
d) Voltage becomes zero immediately

Question 28: A small anaerobic digester at a farm produces biogas that smells. Which operational change most reduces odor and increases methane yield?
a) Keep digestion anaerobic with adequate retention time, control feedstock mix (carbon: nitrogen) and avoid aerobic leaks; capture and combust biogas properly
b) Vent all gas to atmosphere
c) Add only water and ignore solids
d) Open digester daily to air

Question 29: In robotic localization, particle filters are used because they:
a) Represent arbitrary multimodal belief distributions and can recover from non-Gaussian uncertainties
b) Always converge to a single correct particle regardless of motion model
c) Require no resampling step ever
d) Use deterministic closed-form solutions only

Question 30: For additive manufacturing (FDM 3D print), which print parameter most directly reduces warping of large flat parts?
a) Decrease bed temperature to near ambient
b) Use a heated build chamber or heated bed and control cooling rate (reduce thermal gradients)
c) Remove adhesion aids like brim or raft
d) Increase fan speed to maximum immediately

Question 31: A conductor of length 0.5 m moves at 2 m/s perpendicular to B = 0.8 T. Induced emf = B L v. Compute emf.
a) 0.8 V
b) 0.64 V
c) 0.08 V
d) 0.16 V

Question 32: In experiment replication, when an independent team fails to reproduce a claimed effect, best interpretation is:
a) Investigate methodological differences, statistical power, and possible context dependence before concluding original was false
b) Immediately declare original fraudulent
c) Ignore replication entirely
d) Demand that replication use exactly the same lab staff

Question 33: A microcontroller uses PWM to control motor speed. Which is a primary advantage of PWM?
a) Enables efficient control of average voltage/current with low switching losses
b) Causes high continuous power loss by design
c) Eliminates need for a power supply
d) Converts DC to AC for motors only

Question 34: In designing a wind turbine experiment, which variable is best controlled if you want to isolate blade pitch effect on power?
a) Keep wind speed, rotor diameter, and air density as constant as possible while varying pitch
b) Vary pitch and wind speed simultaneously
c) Ignore blade surface condition
d) Change materials randomly

Question 35: A coil with inductance 2 mH carries current that changes at 300 A/s. Induced emf across coil (magnitude) = L·(dI/dt). Compute magnitude.
a) 0.6 V
b) 6 V
c) 0.006 V
d) 600 V

Question 36: A compact water treatment system must achieve safe drinking water in remote village. Which combined approach is most sustainable?
a) Multi-barrier approach: source protection, sedimentation/filtration, low-energy disinfection (solar UV or chlorination), and community maintenance training
b) Use only bottled water shipped weekly
c) Install complex high-tech membrane systems with no local servicing plan
d) Build a single open tank with no treatment

Question 37: A PID controller has Kp = 2, Ki = 1, Kd = 0.5. Which term primarily reacts to the rate of error change and dampens oscillation?
a) Proportional term (Kp)
b) Integral term (Ki)
c) Derivative term (Kd)
d) Feedforward term

Question 38: In engineering drawings, GD&T (geometric dimensioning & tolerance) primarily helps with:
a) Precisely communicating allowable form, orientation, and location variations to ensure proper assembly
b) Replacing all manufacturing instructions with a picture only
c) Eliminating need for inspection
d) Making designs intentionally ambiguous

Question 39: Two parallel wires separated by 10 cm carry currents in opposite directions; which interaction occurs?
a) They repel each other (opposite currents repel)
b) They attract always regardless of direction
c) They neither attract nor repel
d) They produce only electric fields not magnetic

Question 40: A student fits a linear model and obtains $R^2 = 0.02$. Which is the best conclusion?
a) The model explains very little variance — consider alternative predictors or non-linear relationships
b) The model is perfect
c) Increase sample size will change R^2 to 1 automatically
d) Remove all predictors to improve R^2

Question 41: When designing robot gripper fixtures, which factor most reduces part slippage?
a) Increase contact area and use compliant or high-friction materials on contact surfaces
b) Reduce contact area intentionally
c) Use polished steel fingertips only
d) Avoid sensors

Question 42: A charged particle moves perpendicular to a magnetic field and follows a circular path. Radius r depends on:
a) $r = \frac{mv}{qB}$ (mass m, velocity v, charge q)
b) $r = qB/(mv)$
c) $r = v/(mqB)$
d) $r = m + v + q + B$

Question 43: A greenhouse reduces energy use by adding thermal curtains that trap heat at night. Which additional action most improves energy performance?
a) Insulate foundations and recover daytime solar heat with thermal mass to reduce heating needs at night
b) Paint plants black to absorb heat
c) Remove all windows to save glass cost
d) Increase night-time artificial lighting only

Question 44: In robot perception, increasing sensor resolution doubles data size and processing latency. Which trade-off approach is sensible?
a) Apply selective ROI processing and lightweight feature extraction to keep relevant details while reducing processing load
b) Process everything at full resolution always despite latency
c) Reduce resolution to zero
d) Add random noise to reduce size

Question 45: A conductor loop in changing magnetic flux experiences induced current. Lenz's law states the induced current:
a) Produces a magnetic field opposing the change in flux
b) Always amplifies the change in flux
c) Has no relation to flux change
d) Points randomly

Question 46: A prototype uses lithium-ion cells. Which BMS (battery management system) feature is most critical for safety?
a) Cell balancing, over-charge and over-discharge protection, and temperature monitoring
b) No monitoring
c) Only a decorative cover over pack
d) Use larger unregulated charger

Question 47: A dataset shows two variables correlated at r = 0.85. Which is true?
a) Strong linear association, but correlation does not imply causation — investigate confounders and directionality
b) Variable X causes Y automatically
c) r = 0.85 means variables are identical
d) Correlation can be ignored always

Question 48: In designing experiments with human subjects, which is essential ethical practice?
a) Obtain informed consent and ensure confidentiality and safety monitoring
b) Hide risks from participants to get honest behaviour
c) Force participation for quicker results
d) Publish personal data without permission

Question 49: In a DC circuit, two 6 V batteries are connected in series and a 12 Ω resistor is connected across them. What is current?
a) 1 A
b) 2 A
c) 0.5 A
d) 12 A

Question 50: For product sustainability assessment, which lifecycle stage often yields the largest environmental impact for electronics?
a) Manufacturing (materials extraction and production) often dominates, though use and end-of-life also matter depending on design
b) Packaging only
c) User manual printing only
d) Retail shelf placement only

Question 51: A mobile robot must follow a path with curvature κ(s). For differential drive kinematics, turning rate ω relates to wheelbase L and forward speed v by:
a) $\omega = \kappa(s)\, v$ (curvature times speed)
b) $\omega = L + v$
c) $\omega = v/L^2$
d) $\omega = 0$ always

Question 52: In prototyping electronics, decoupling capacitors near IC power pins primarily:
a) Provide local charge during fast transients and reduce supply noise
b) Serve as memory for the IC
c) Slow down the processor intentionally
d) Replace fuses

Question 53: A river restoration project aims to reduce sediment load entering a reservoir. Which upstream action is most effective?
a) Implement riparian buffer strips, reforestation, and erosion control on slopes upstream
b) Dredge the reservoir daily only
c) Build permanent concrete walls at the reservoir edge only
d) Divert the river permanently

Question 54: A solenoid with N turns and current I produces magnetic field inside approx. proportional to:
a) $B \propto \mu_0 NI/\ell$ (where ℓ is solenoid length)
b) $B \propto N + I$ only
c) B independent of N
d) $B \propto 1/(NI)$

Question 55: Which prototyping method best supports rapid functional testing of an electronic control board?
a) Breadboard or modular development board for quick iteration before committing to PCB fabrication
b) Immediately make 200 production PCBs without testing
c) Use nails and string for circuits
d) Prototype in final rugged enclosure only

Question 56: A transformer's primary has 100 turns, secondary 250 turns. If primary RMS voltage is 120 V, ideal secondary RMS ≈:
a) 300 V
b) 120 V
c) 48 V
d) 250 V

Question 57: To remove nitrates from groundwater at community scale, an effective method is:
a) Ion-exchange or biological denitrification systems tailored to scale and cost
b) Boiling water (does not remove nitrates)
c) Adding table salt to neutralize nitrates
d) Painting wells white

Question 58: In algorithmic control for robot path smoothing, which approach reduces high-frequency oscillations while preserving path shape?
a) Apply low-pass filtering or spline smoothing with controlled smoothing parameter
b) Amplify high-frequency noise deliberately
c) Replace path with random waypoints
d) Use only straight lines between extremes

Question 59: A 10-turn loop area 0.02 m^2 is in a field changing at 0.5 T/s. Induced emf magnitude ≈ N·A·(dB/dt). Compute emf.
a) 0.1 V
b) 0.01 V
c) 0.001 V
d) 1 V

Question 60: A city plans to reduce urban heat island effect. Which combined measures are most effective?
a) Increase urban tree canopy, cool/reflective roofs, and permeable surfaces to reduce absorbed heat and increase evapotranspiration
b) Pave more dark asphalt to increase heat capacity
c) Remove all parks to build malls
d) Increase outdoor lighting at night

ROUGH WORK
(NOT TO BE EVALUATED)

DATE