

Sample examination papers

Internet of Things and Robotics: mid-semester and end-semester

IoT and Robotics crash course

2026-10-11

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These papers are **samples** built from the question bank. The syllabus weights are: continuous assessment 30%, laboratory 20%, mid-semester 15%, end-semester 25%, capstone 10%. Numbers in the answers are computed by the course code; see the answer key.

Mid-semester paper (Units 1 to 5)

Time: 90 minutes. **Maximum marks:** 50. Answer all questions. Marks are shown after each question.

1. In the four-layer architecture of an IoT system, a soil-moisture node belongs to the: *(1 mark; Unit 1)*
 - (A) Device layer
 - (B) Cloud layer
 - (C) Network layer
 - (D) Edge layer
2. A node sends a 20-byte payload with 10 bytes of overhead every 60 s. How many bytes does it send in a day? *(2 marks; Unit 1)*
3. A bang-bang thermostat with a hysteresis band swings wider than the band when its sensor reading is delayed. Why? *(3 marks; Unit 1)*
4. A room obeys $dT/dt = -(T - T_{\text{out}})/\tau + k u$ with $\tau = 60$ min, $k = 0.5$ degC/min, $T_{\text{out}} = 5$ degC. With the heater on, how long does it take to warm from 15 to 21 degC? *(4 marks; Unit 1)*
5. A 3.3 V supply drives an LED (forward drop 2.0 V) at 10 mA. What series resistor? *(1 mark; Unit 2)*
6. A divider of 10 kohm (top) and 20 kohm (bottom) is fed from 5 V. What is the output unloaded, and with a 20 kohm load across the bottom resistor? *(2 marks; Unit 2)*

7. A node wakes for 0.2 s at 50 mA, connects for 1.3 s at 100 mA, publishes for 0.3 s at 140 mA, shuts down for 0.2 s at 50 mA and sleeps 58 s at 0.01 mA. Average current and life of a 2000 mAh battery (80% usable)? (3 marks; Unit 2)
8. A motor needs an average of 6 V. The pack is 7.4 V. What PWM duty is needed if the bridge drops 0.4 V, and what if the bridge drops 2 V? (4 marks; Unit 2)
9. A sensor reads 25.3, 25.2, 25.3, 25.2 when the true value is 20.0. It is: (1 mark; Unit 3)
- (A) Accurate but not precise
 - (B) Precise but not accurate
 - (C) Neither precise nor accurate
 - (D) Both accurate and precise
10. A soil sensor reads raw 1200 in air (0%) and 3000 in water (100%). Using a two-point linear calibration, what is the reading for raw 2100? (2 marks; Unit 3)
11. An exponential filter is designed for a time constant of 5 s at a 1 s sample period. Give its coefficient and the factor by which it reduces white-noise variance. (3 marks; Unit 3)
12. A 1320 counts-per-revolution encoder is on a wheel of radius 33 mm. What distance does one count represent, and what is the speed resolution if speed is the count change over 100 ms? (4 marks; Unit 3)
13. A mechanical button is debounced to: (1 mark; Unit 4)
- (A) Make it press harder
 - (B) Ignore the rapid on-off bounces so one press counts once
 - (C) Save battery in deep sleep
 - (D) Raise the logic voltage
14. How many bits does one UART byte occupy on the wire in the 8N1 format, and how long does it take at 115200 baud? (2 marks; Unit 4)
15. An encoder produces 7643 transitions per second and the interrupt handler takes 5 microseconds. What fraction of the CPU does it use? (3 marks; Unit 4)
16. A node retries a failed publish up to 3 times and each attempt fails with probability 0.3, independently. What fraction of cycles delivers? (4 marks; Unit 4)
17. Which MQTT quality-of-service level guarantees delivery at least once? (1 mark; Unit 5)
- (A) None of them
 - (B) QoS 1
 - (C) QoS 0
 - (D) Only QoS 2
18. How many bytes is an MQTT PUBLISH at QoS 1 with the 10-byte topic 'gh/p1/soil' and a 7-byte payload (fixed header, length fields and packet id included)? (2 marks; Unit 5)
19. Free-space path loss at 100 m and 2.4 GHz? (3 marks; Unit 5)
20. Does the subscription 'greenhouse/+ /soil' receive a message published on 'greenhouse/zone1/soil/raw'? What would match both? (4 marks; Unit 5)

End-semester paper (Units 1 to 12, weighted to Units 6 to 12)

Time: 180 minutes. **Maximum marks:** 100. Answer all questions. Marks are shown after each question.

1. A battery of 2000 mAh (80% usable) feeds a load of 100 mA average. How long does it last? (2 marks; Unit 1)
2. A room obeys $dT/dt = -(T - T_{\text{out}})/\tau + k u$ with $\tau = 60$ min, $k = 0.5$ degC/min, $T_{\text{out}} = 5$ degC. With the heater on, how long does it take to warm from 15 to 21 degC? (4 marks; Unit 1)
3. A 12-bit ADC has a 3.3 V reference. Give the size of one step (LSB) and the RMS quantisation error of an ideal converter. (2 marks; Unit 2)
4. A motor needs an average of 6 V. The pack is 7.4 V. What PWM duty is needed if the bridge drops 0.4 V, and what if the bridge drops 2 V? (4 marks; Unit 2)
5. A 70 Hz signal is sampled at 100 Hz. At what frequency does it appear? (2 marks; Unit 3)
6. A 1320 counts-per-revolution encoder is on a wheel of radius 33 mm. What distance does one count represent, and what is the speed resolution if speed is the count change over 100 ms? (4 marks; Unit 3)
7. Using the course's I2C model, how long does a 2-byte read take at a 100 kHz clock? (2 marks; Unit 4)
8. A node retries a failed publish up to 3 times and each attempt fails with probability 0.3, independently. What fraction of cycles delivers? (4 marks; Unit 4)
9. With independent loss $p = 0.1$ per packet, how many packets (both directions) does one QoS 1 message cost on average, with unlimited retries? (2 marks; Unit 5)
10. Does the subscription 'greenhouse/+ /soil' receive a message published on 'greenhouse/zone1/soil/raw'? What would match both? (4 marks; Unit 5)
11. Compared with JSON, CBOR is mainly: (1 mark; Unit 6)
 - (A) A database
 - (B) A different network protocol
 - (C) A more compact binary encoding of the same kinds of data
 - (D) An encryption standard
12. For the reading {zone: 1, soil_raw: 1832, temp_c: 21.5, batt_v: 3.71}, how many bytes does it take as compact JSON, as CBOR and as the packed binary of the course? (2 marks; Unit 6)
13. A z-score alarm at $k = 3$ on Gaussian noise is checked once a minute for one zone. How many false alarms per day should you expect? (3 marks; Unit 6)
14. Which detector finds a small persistent shift in the mean sooner, an EWMA or a CUSUM, for the same false-alarm rate, and why? (4 marks; Unit 6)
15. The Mirai botnet spread mainly by: (1 mark; Unit 7)
 - (A) Phishing e-mails
 - (B) A zero-day in the TCP stack
 - (C) Physical access
 - (D) Logging in to devices with default credentials

16. How many bits of entropy has a random password of 8 lowercase letters? (2 marks; Unit 7)
17. A command is authenticated by an HMAC truncated to 8 bytes, or to 4 bytes. What is the probability that one random guess of the tag is accepted? (3 marks; Unit 7)
18. Why does the course put TLS on the gateway rather than on the battery node, and how does the node still authenticate commands? (4 marks; Unit 7)
19. How many degrees of freedom has a planar 2-link arm (two revolute joints)? (1 mark; Unit 8)
- (A) 2
 - (B) 4
 - (C) 3
 - (D) 1
20. A 2-link arm with links 0.30 m and 0.20 m has joint angles 30 and 45 degrees. Where is the tip? (2 marks; Unit 8)
21. Inverse kinematics (elbow up) for the target (0.35, 0.20) m with links 0.30 and 0.20 m: give both joint angles in degrees. (3 marks; Unit 8)
22. The right wheel of a rover is 0.5% larger than assumed (left exact), track 0.16 m, and the odometry believes it drove 20 m straight. How far is the true end point from where the odometry says it is? (4 marks; Unit 8)
23. A proportional-only controller on a motor speed loop leaves: (1 mark; Unit 9)
- (A) A steady-state error
 - (B) Only overshoot
 - (C) No error ever
 - (D) An unstable loop at every gain
24. A plant has DC gain $K = 3.491$ rad/s per volt. With P control $K_p = 1$, what fraction of the setpoint is the steady-state error? (2 marks; Unit 9)
25. For the wheel loop (10 ms sample, one sample of delay) the course finds the ultimate gain from the loop's characteristic polynomial. Give K_u (V per rad/s) and the oscillation period. (3 marks; Unit 9)
26. The rover brakes at the traction limit with $\mu = 0.6$ from 0.5 m/s. If the reaction takes 150 ms, how far does it travel from detection to rest? (4 marks; Unit 9)
27. For Gaussian noise, the fraction of readings within two standard deviations of the mean is about: (1 mark; Unit 10)
- (A) 99.7%
 - (B) 50%
 - (C) 68%
 - (D) 95%
28. Dry soil has a 5% prior. A sensor flags 'dry' in 90% of dry cases and 8% of wet ones. What is $P(\text{dry})$ after one flag? (2 marks; Unit 10)
29. A scalar Kalman filter has process variance $q = 1e-4$ per step and measurement variance $r = 0.04$. What is its steady-state gain, and the equivalent EMA coefficient? (3 marks; Unit 10)

30. Why was the course's EKF overconfident about its position along the wall, though accurate across it? (4 marks; Unit 10)

31. Which search is guaranteed to find the path with the fewest steps on an unweighted grid? (1 mark; Unit 11)

- (A) Depth-first search
- (B) Breadth-first search
- (C) Greedy best-first search
- (D) Random walk

32. On an 8-connected grid the goal is 7 cells right and 2 up. Give the octile heuristic. (2 marks; Unit 11)

33. The rover brakes at $\mu = 0.6$ from 0.5 m/s with a 15 ms edge loop. What is the longest ultrasonic ping period that still stops it within 5 cm in the worst case? (3 marks; Unit 11)

34. A watchdog stops the rover when no command arrives for 0.2 s. At 0.5 m/s (15 ms edge loop, $\mu = 0.6$), how far does it travel after the last good command? (4 marks; Unit 11)

35. In the capstone, 'coverage' means the fraction of: (1 mark; Unit 12)

- (A) Plant-hours with moisture at or above the dry threshold
- (B) Battery charge left
- (C) Messages that arrive
- (D) Floor area the rover visits

36. MQTT QoS 1 tries a PUBLISH up to 5 times; each attempt is lost with probability 0.3. What fraction of messages is lost for good? (2 marks; Unit 12)

37. Over 40 days the success rate has a mean of 99.6% and a 95% interval of ± 0.8 percentage points (1.96 s/sqrt(n)). What is the standard deviation of the daily success rate? (3 marks; Unit 12)

38. The first end-to-end design served only 78% of dry events within 30 minutes although every component passed its tests. What was wrong and how was it fixed? (4 marks; Unit 12)