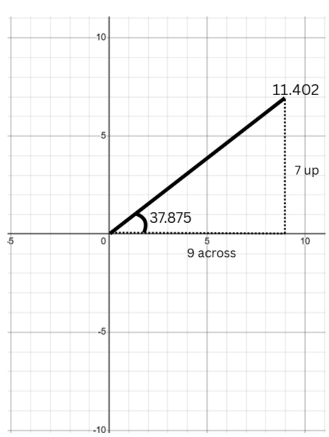
Expanded Mark Scheme – T-Level Example Mock 1

Q	Expanded Answer Guidance	Marks
1a	$1_{ft} = 0.3048_m$ $12_{ft} = 12 * 0.3048_m$ $12_{ft} = 3.6576_m$	1
1b	Reasons for conversion: • Standardisation • Avoids engineering errors • SI units are standard in engineering • To make sure the beam fits the design • To ensure structure is built safely • To match engineering drawings	1
2a	$\vec{A} = 6i + 2j$ $\vec{B} = 3i + 5j$ $\vec{R} = (6+3)i + (2+5)j$ $\vec{R} = 9i + 7j$	1
2b	Magnitude: $\lvert R \rvert = \sqrt{9^2 + 7^2} = 11.40175425$ Angle: $\tan^{-1}\left(\frac{7}{9}\right) = 37.87498365$ $\vec{R} = 11.402\angle 37.875$ Note: Carry on marks are allowed if wrong answer is got in part a but correct method is used Magnitude and angle marks are for method rather than result	1 mark for magnitude 1 mark for angle 1 mark for answer
2c	 Note: the 9 across and 7 up do not have to be drawn or written, they are just there to show how to draw it Carry on marks are allowed if wrong answer is got in part a or b but line is correctly drawn and labelled	1 mark for drawing the line 1 mark for including correct labels

3a	Parallel resistance: $\frac{1}{\frac{1}{120}+\frac{1}{300}} = 85.71428571$ Series resistance: $85.71428571 + 560 = 645.7142857$	1 mark for method 1 mark for answer
3b	• Ammeter • Connected in series Accept: • Multimeter	2
3c	$V = IR$ $10 = 645.7142857I$ $I = \frac{10}{645.7142857} = 0.01548672566A$ $0.01548672566A = 15.486mA$ Carry on marks are allowed if wrong answer is got in part a but correct method is used	1
4a	Gear ratio: $\frac{teeth\ on\ driven}{teeth\ on\ driver} = \frac{60}{20} = 3$	1
4b	$Output\ Speed = \frac{input\ speed}{gear\ ratio} = \frac{900}{3} = 300$ Carry on marks are allowed if wrong answer is got in part a but correct method is used	2
5a	Iron core: • Increases permeability • Concentrates magnetic flux • Strengthens magnetic field • Iron core is a magnetic material • Iron is ferromagnetic	2 marks, 1 for each point raised
5b	$\boldsymbol{H = \frac{NI}{L}}$ $\boldsymbol{H = \frac{500 * 2}{0.25} = 4000A/m}$	1 mark for method 1 mark for answer
5c	Ways to improve field strength: • Increase current • Increase turns • Better core material • Reduce solenoid length	2

6a	Electrical conduction requires: • Free charge carriers • Electrons able to move • Delocalized electrons • A potential difference is applied (voltage) meaning current flows	2
6b	Valence band: • Electrons are held/bound to atoms Conduction band: • Electrons are free to move and contribute to conduction Conductor: • No/small band gap • Band gaps overlap • Conduction band is partially filled • Electrons move easily Semiconductor: • Small band gap • Electrons can gain enough energy and become delocalized • Conductivity with energy Insulator: • Large band gap • Very few electrons can become delocalized • Poor conductivity	5
6c	Silicon: • Is a semiconductor • Gains energy from heat/light • Electrons move to conduction band from the valence band • More free charge carriers due to electrons in the conduction band • Electrons leave holes which act as positive charge carriers • Conductivity increases	4

7a	**Indicative content:** Hydraulics: • Hydraulics use hydraulic fluid to perform actions with pumps pushing fluid around • Hydraulics are good for heavy lifting • Hydraulics could leak and contaminate biscuits, packaging, machinery and work surfaces. • Hydraulic fluid near food creates hygiene and cleaning issues • Hydraulics may be excessive for lightweight biscuit trays • Hydraulics require maintenance such as checking seals, hoses, pumps, filters and fluid levels Pneumatics: • Pneumatic systems use air to perform actions with compressors needed to compress the air • Pneumatics are good for fast, repetitive movements • Pneumatics are cleaner than hydraulics but would need air quality checks like filters and dryers • Pneumatics are good for food processing as leaks are usually less hazardous than hydraulic fluids • Pneumatics are often less precise that electrical systems due to air compressibility Electrics: • Electrics use current to perform actions and need voltage sources to perform actions • Electric actuators are good for accurate positioning, controlled speed, rotary motion and repeatable movement. • No risk of contamination of food • Risk from overheating, sparks or other faults causing fires with cardboard packaging • Easier to control with a controller like PLCs or Microcontrollers Conclusion: • A strong answer may include a mixed system with hydraulic actuators for fast linear actions and electric actuators for precise motion Band 1 (1–3): • Basic comparison Band 2 (4–6): • Clear pros/cons • Some application to biscuit facility Band 3 (7–9): • Detailed engineering comparison • Discusses cleanliness, safety, maintenance, efficiency • Justifies suitable option	

8a	**Indicative content:** PLCs: • A PLC is designed for industrial automation and continuous operation. • PLCs are suitable for systems with many inputs/outputs such as an airport conveyor and screening system • PLCs are easier to fault find because the technician can monitor the program, I/O and diagnostic messages • PLCs are more suited for safety critical systems which the scenario is • PLCs are expandable if the airport needs extra conveyors or screening equipment. • PLCs are more expensive than microcontrollers but the cost is justified Microcontrollers: • Microcontrollers are much cheaper, compact and useful for embedded systems • Could fit in the smaller modules eg barcode scanners, sensor units or displays • A microcontroller would need a lot of additional components to meet the requirements of a full baggage system • Usually much harder to maintain and troubleshoot Conclusion • A strong answer may suggest a dual control system with PLCs for the main control and microcontrollers used for smaller parts Band 1 (1–3): • Basic PLC vs microcontroller comparison Band 2 (4–6): • Reliability, diagnostics, industrial suitability Band 3 (7–9): • Detailed industrial comparison • Maintenance, uptime, expandability, troubleshooting • Justifies best option	9

9a	**Indicative content:** Sensors: • System might use a camera for detecting approaching visitors • System might use an encoder to determine where the head had turned to • System might use a limit switch to determine when the head has reached a position • System might use and ultrasonic sensor to detect how close a visitor is • System might use a light gate to determine when a visitor is approaching or too close Actuators: • System might use a servo or other motor type to control the head movement • System might use LEDs to light up the eyes • System might use a speaker to play the roar sound • System might use linear actuators to raise the arm / jaw Sequence: • Describes a sensible sequence, for instance: - visitor detected - safety zone checked - eyes turn on - head turns - jaw opens - roar sound plays - arm moves - jaw closes - arm and head return to home position - system resets when visitor leaves Safety: • Describes how movement should stop when someone enters zone Controller: • System might use a PLC, Computer or Microcontroller to control its movement • Sufficient consideration has been put into what controller to use Band 1 (1–4): • Basic system design, some consideration into sensors, actuators Band 2 (5–8): • Suitable sensors/actuators • Some operation and safety Band 3 (9–12): • Full system design • Appropriate sensors and actuators and controller • Clear sequence • Strong safety considerations • Diagrams integrated with explanation	12