Name	Score
	/63

Question 1

a) An engineer measures a steel support beam as 12 ft long. Convert this length into metres. (1 mark)

Use: 1 ft = 0.3048 m.

b) Explain one reason why converting the beam length from feet to metres is important. (1 mark)

Question 2

Two forces act on a bracket:

$$\vec{A} = 6i + 2j$$

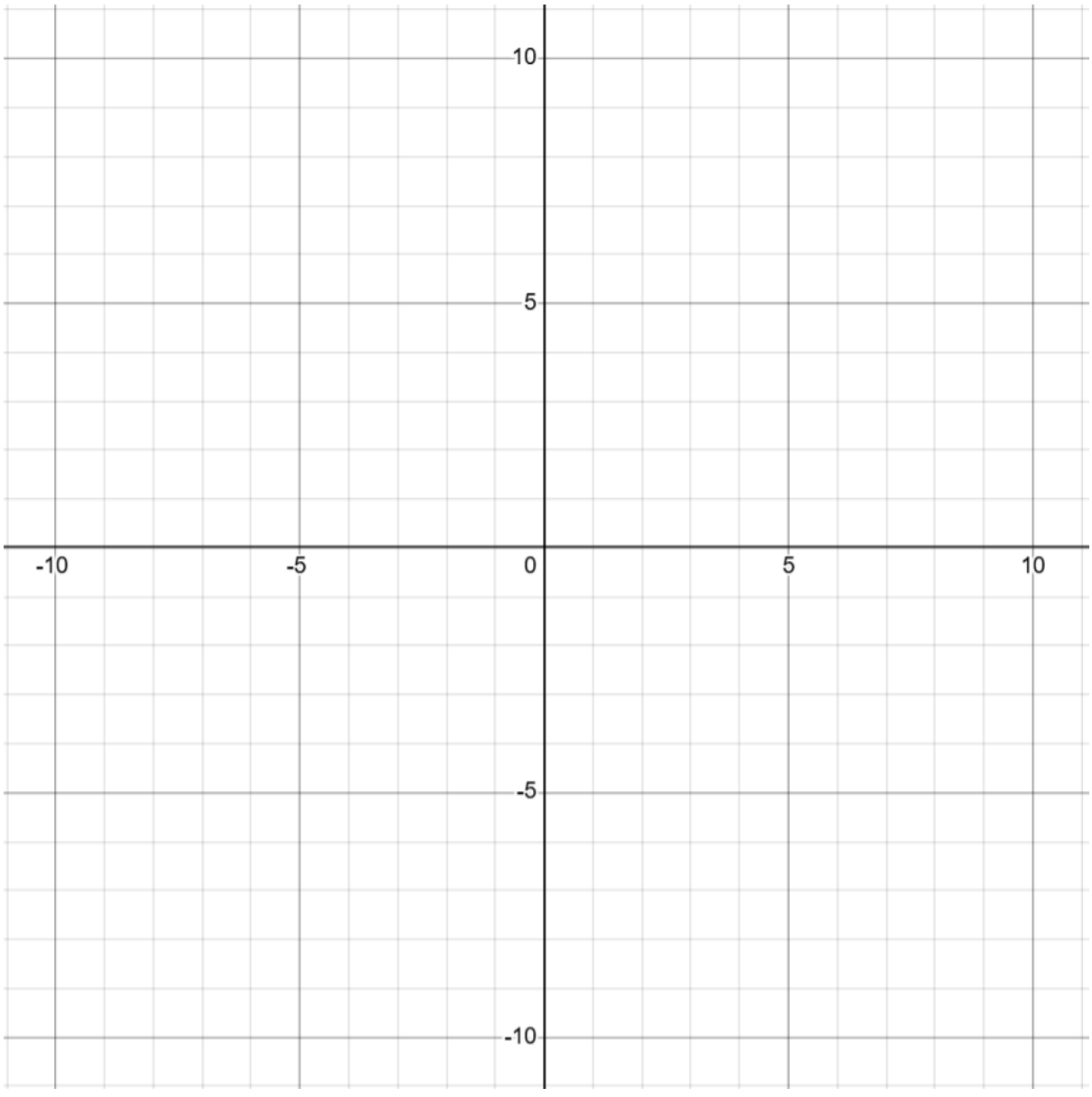
$$\vec{B} = 3i + 5j$$

a) Calculate the resultant vector

Type equation here. $\vec{R}$ in cartesian form. (1 mark)

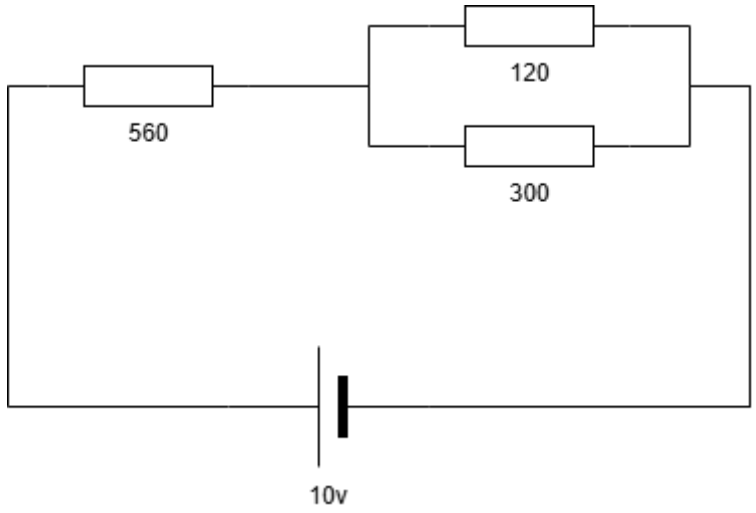
b) Convert the resultant vector into polar form, giving the magnitude and angle from the positive x-axis (3 marks)

c) On the graph below, draw the resultant vector $\vec{R}$ from the origin. Label its magnitude and the angle it makes with the positive x-axis. (2 marks)



Question 3

An engineer has built the following resistor circuit:



a) What is the total resistance of the circuit? (2 marks)

b) The engineer wants to measure the current flowing through the 560-ohm resistor. State the device used and how it should be connected. (2 mark)

c) Calculate the current that the engineer would measure. (1 mark)

Question 4

A motor drives a gear with 20 teeth. This gear turns a larger gear with 60 teeth connected to a conveyor system.

a) Calculate the gear ratio (1 mark)

b) If the motor gear rotates at 900 rpm, calculate the speed of the larger gear. (2 marks)

Question 5

An engineer is testing a solenoid used in an electromagnetic locking system. The solenoid contains a coil of wire wrapped around an iron core. When current flows through the coil, a magnetic field is produced.

a) Explain why placing an iron core inside the solenoid increases the strength of the magnetic field. (2 marks)

b) The solenoid has 500 turns and is 0.25 m long. A current of 2.0 A flows through the coil.

The magnetic field strength inside a solenoid can be calculated using:

$$\boldsymbol{H = \frac{NI}{L}}$$

Calculate the magnetic field strength inside the solenoid. (2 marks)

c) What could the engineer do to improve the magnetic field strength? (2 marks)

Question 6

a) Explain what must be present in a material for electrical conduction to occur. (2 marks)

b) Explain how the arrangement of the valence band, conduction band, and energy gap affects whether a material behaves as a conductor, semiconductor, or insulator. (5 marks)

c) Silicon is used in many electronic components. Explain why silicon can conduct electricity better when energy is supplied to it. (4 marks)

Question 7

A company operates a biscuit packing facility. Biscuits are baked, cooled, counted, packed into plastic trays, wrapped, and then placed into cardboard boxes for shipping. The system needs to operate quickly and repeatedly throughout the day.

The company wants to install an automated handling system. The system will use several actuators including linear, rotary, gripper, lifting and diverting actuators.

The engineering team must decide whether the system should use hydraulic, pneumatic or electric power transmission.

a) Compare the suitability of hydraulic, pneumatic, and electric power transmission for the biscuit packing facility. Giving pros and cons for each.

Consider the process, packaging, contents and other requirements in your answer. (9 marks)

Question 8

A company is designing an automated airport baggage handling and security screening system.

The system must move suitcases from the check-in desks to the correct aircraft loading area. Along the route, the system uses:

- barcode scanners to identify each bag
- conveyors to move bags between zones
- diverter arms to send bags down different routes
- weight sensors to detect overloaded bags
- photoelectric sensors to detect jams
- emergency stop buttons along the conveyor line
- warning beacons and alarms
- a touchscreen operator panel for maintenance staff

The system must run for long periods with minimal downtime. If a fault occurs, maintenance technicians need to identify the problem quickly so that baggage delays are reduced.

The design team is considering two possible control solutions:

1. a PLC-based control system
2. a microcontroller based control system

a) Compare the suitability of using a PLC and a microcontroller for the airport baggage handling and screening system. (9 marks)

Question 9

A science museum wants to create an interactive animatronic dinosaur display for its entrance area.

When a visitor walks near the display, the dinosaur should:

- turn its head towards the visitor
- open its mouth
- play a short roar sound
- move one arm
- light up its eyes
- then return to its starting position after the visitor leaves

The system must be safe because young children may stand close to the display. It should not move if someone is too close to the moving parts.

a) Design a control system for the animatronic dinosaur display. (12 marks)
In your answer, you should include:

- suitable sensors and where they would be positioned
- suitable actuators and what they would control
- the sequence of operation
- safety features needed
- reasons why your chosen sensors and actuators are suitable

Your answer space has room for diagrams and drawings as well as written text.

Diagrams/Drawings