Question Number	Answer		Mark
2(a)	• Measure x with a metre rule • Ensure the moveable rod is perpendicular to the fixed rods (e.g. use a set-square) **Or** measure x on both 30 cm rods and calculate the average **Or** measure to the centre of the moveable rod **Or** align the metre rule near to the 30 cm rod **Or** measure x while looking perpendicularly at the metre rule • Check for zero error on ohmmeter **Or** choose appropriate range on ohmmeter **Or** repeat R readings and calculate mean R for same value of x • Minimise contact resistance (e.g. ensure rods are clean)	**(1)** **(1)** **(1)** **(1)**	**4**
2(b)	**Max 1 of** • (When x = 0 m) the ohmmeter will measure the resistance of the (moveable) copper rod • Zero error in ohmmeter • The connecting leads have a resistance	**(1)** **(1)** **(1)**	**1**
2(c)	**EITHER** • Use of $A = \pi r^2$ (accept $A = \pi d^2 / 4$) • Use of $l = 2x + 0.05$ m • Use of $R = \rho l/A$ (with a pair of values from the line of best fit) • $\rho = 1.7 \times 10^{-8}\ \Omega$ m Accept use of x = 0 (l = 0.05 m) for MP2 and correct calculated value for MP4 **OR** • Use of $A = \pi r^2$ (accept $A = \pi d^2 / 4$) • Calculates gradient • Use of gradient = $2\rho/A$ • $\rho = 1.7 \times 10^{-8}\ \Omega$ m <u>Example of calculation</u> $A = \pi r^2 = \pi \times (0.0015\text{ m})^2 = 7.1 \times 10^{-6}\text{ m}^2$ $l = 2x + 0.05 = (2 \times 0.25\text{ m}) + 0.05\text{ m} = 0.55\text{ m}$ $\rho = RA/l = (1.3 \times 10^{-3}\ \Omega \times 7.1 \times 10^{-6}\text{ m}^2) / 0.55\text{ m} = 1.68 \times 10^{-8}\ \Omega$ m OR $A = \pi r^2 = \pi \times (0.0015\text{ m})^2 = 7.1 \times 10^{-6}\text{ m}^2$ Gradient = $(1.55 \times 10^{-3}\ \Omega - 0.35 \times 10^{-3}\ \Omega)/(0.3\text{ m} - 0.05\text{ m}) = 4.8 \times 10^{-3}\ \Omega\text{ m}^{-1}$ ρ = gradient × $A/2$ = $1.70 \times 10^{-8}\ \Omega$ m	**(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(1)**	**4**
2(d)	• As the cross-sectional area decreases the resistance (per unit length of track) increases • The system will estimate the position of the train is further away than it actually is **Or** the train is actually closer than the system estimates it to be MP2 dependent on MP1	**(1)** **(1)**	**2**
	Total for question 2		**11**