

## MARKING SCHEME

Part			Total points
<b>A. Understanding of magnetic fields</b>			<b>1.0</b>
<b>A.1</b>	Value	$k = 6.28 \times 10^{-3} \text{ mT/mA}$	0.5
		Correct	0.5
		Incorrect	-0.5
		No unit	-0.25
<b>A.2</b>	Formula	$B_{\beta} = B_h \cos \beta$	0.5
		Correct	0.5
		Incorrect	-0.5
<b>B. Investigation of the GMR effect using a GMR magnetic sensor</b>			<b>7.0</b>
<b>B.1</b>	Diagrams and expressions	Diagrams and expressions	1.25
		Correct	1.25
		Incorrect	-1.25
<b>B.2</b>	Values	Resistance of $a, b, c, d$ . The four resistances are nearly equal.	1.25
		$4800 < r < 5200$	1.2
		$4500 < r < 4800$ or $5200 < r < 5500$	-0.25
		$4000 < r < 4500$ or $5500 < r < 6000$	-0.5
		$r < 4000$ or $r > 6000$	-1.25
		No units	-0.5
<b>B.3</b>	Values	Resistance of $a, b, c, d$ .	0.5
		Correct	0.5
		For $b$ and $d$	
		Correct if $4800 < r < 5200$	0.25
		$r < 4800$ or $r > 5200$	-0.25
		For $a$ and $c$	
		Correct if $4100 < r < 4500$	0.25
$r < 4100$ or $r > 4500$	-0.25		
<b>B.4</b>		$a$ and $c$ are sensitive	0.25
		Correct	0.25
		Other	-0.25

<b>B.5</b>	Diagrams and expressions	Diagrams and expressions		0.75	
		Correct	0.75		
		Incorrect	-0.75		
<b>B.6</b>	Table	Table		1.25	
		At least 15 points, whole range of $B$	1.25		
		Less than 15 points	-0.25		
		Less than 10 points	-0.5		
		Less than 5 points	-1.25		
		Less than $2/3$ range of $B$	-0.5		
		Less than 0.5 range of $B$	-1.25		
<b>B.7</b>	Graph	Graph 1		0.5	
		Correct	0.5		
		No units	-0.15		
		Less than $2/3$ area of the sheet	-0.15		
<b>B.8</b>	Values	$\alpha = -0.067 \text{ mT}^{-1}$		0.25	
		Correct	0.25		
		No units	-0.1		
		No sign	-0.1		
		$ \alpha  < 0.05$ or $ \alpha  > 0.08$	-0.15		
<b>B.9</b>		$\delta = 13.5\%$		0.25	
		Correct: $12 < \delta < 15$ , sign not important	0.25		
		Out of range	-0.25		
<b>B.10</b>		$r = 3180\Omega$ ; $R = 6740\Omega$ ; $\gamma = \frac{r}{R} = 0.47$		0.75	
		$2900 < r < 3300$ ; $6000 < R < 7000$ ; $0.43 < \gamma < 0.51$	0.75		
		Each of these values out of range	-0.25		
<b>C. Study of GMR magnetic sensor</b>					<b>6.0</b>
<b>C.1</b>	Table	Table		1.0	
		At least 40 points, whole range of $\pm B$	1.0		
		Less than 40 points	-0.25		
		Less than 30 points	-0.5		
		Less than 20 points	-1.0		
		Less than $2/3$ range of $B$	-0.5		
		Less than 0.5 range of $B$	-1.0		

<b>C.2</b>	Graph 2	Graph 2		1.0
		Correct	1.0	
		No units	-0.15	
		Less than 2/3 area of the sheet	-0.15	
<b>C.3</b>	Graph and value			0.5
		Correct regions and value $1.8 \times 10^2 < m < 2.2 \times 10^2$	0.5	
		Error in each region	-0.1	
		$m$ out of range	-0.2	
<b>C.4</b>	Value	$B_c = 0.10 \text{ mT}$		0.5
		Correct: $0.08 < B_c < 0.12$	0.5	
		Out of range	-0.5	
<b>C.5</b>	Table	$S$ and $E$		0.25
		Correct	0.25	
		Less than 4 pts	-0.25	
<b>C.6</b>	Graph	Graph 3		0.25
		Correct	0.25	
		No units	-0.1	
		Less than 2/3 area of the sheet	-0.1	
<b>C.7</b>	Formula	$ S  = \frac{E}{2} \cdot  \alpha  \cdot B$		0.5
		Correct, symbol of absolute value not important	0.5	
		Other	-0.5	
<b>C.8</b>	Diagrams and expressions	Magnetic field used is that of the Earth		0.25
		Correct	0.25	
		Incorrect	-0.25	
		Diagram and expressions		0.75
		Correct	0.75	
		Incorrect	-0.75	
<b>C.9</b>	Table	$B$ and $L_1$		
		At least 8 points, $5 < L_1 < 20$	1.0	
		Less than 8 points	-0.25	
		Less than 4 points	-1.0	
<b>C.10</b>	Graph and value	Graph 4 and value		0.5
		Correct	0.5	
		No units	-0.15	

		Less than 2/3 area of the sheet	-0.15		
		Correct if $n = 0.56$ ; $0.35 < n < 0.75$			
		$n$ out of range	-0.15		
<b>D. Applications of GMR magnetic sensors</b>					<b>6.0</b>
<b>D.1</b>	Diagrams and expressions	Diagram and expressions		0.5	
		Correct	0.5		
		Incorrect	-0.5		
<b>D.2</b>	Value	$B_h = 0.035 \text{ mT}$		0.25	
		$0.025 < B_h < 0.045$	0.25		
		Out of range	-0.25		
<b>D.3</b>	Diagrams and expressions	Diagram and expressions		0.75	
		Correct	0.75		
		Incorrect	-0.75		
<b>D.4</b>	Value	$B_{\text{Earth}} = 0.041 \text{ mT}$ ; $\theta = 31^\circ$		0.5	
		Correct if $0.03 < B_{\text{Earth}} < 0.05$ ; $20^\circ < \theta < 40^\circ$	0.5		
		Out of range of each value	-0.25		
<b>D.5</b>	Diagram	Diagram		0.5	
		Correct	0.5		
		Incorrect	-0.5		
<b>D.6</b>	Table	Table $S$ and $I, U, P$		0.75	
		At least 12 points, $P$ from 0 to larger than 5W.	0.75		
		Less than 12 points	-0.25		
		Less than 8 points	-0.5		
		Less than 5 points	-0.75		
<b>D.7</b>	Graph	Graph 5		0.5	
		Correct	0.5		
		No units	-0.15		
		Less than 2/3 area of the sheet	-0.15		
<b>D.8</b>	Formula	$P = \kappa S$		0.25	
		Correct	0.15		
		Incorrect	-0.15		
	Value	$\kappa = 0.026 \text{ W/mV}$			
		Correct $0.01 < \kappa < 0.05$	0.1		
		Out of range	-0.1		

<b>D.9</b>	Shape	Shape of circuit and direction of current		2.0	
		One shape and direction correct	1.5		
		The second shape and direction correct	0.5		
		Incorrect direction in the first circuit	-0.5		
		Incorrect direction in the second circuit	-0.25		