Marking Scheme

#1

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
4	*(a)*		Align probe for max signal / perpendicular to field (at known distance) (1) Put probe at a fixed/known distance (1) Current calculated from equation $B = \frac{\mu_0 I}{2\pi a}$ (1)	3			3	1	1
	(b)		Use of $F = BIl$ (1) Use of $B = \frac{\mu_0 I}{2\pi a}$ (1) $\left[\text{or } \frac{F}{l} = \frac{\mu_0 I^2}{2\pi a} \text{ for 2 marks}\right]$ Answer = 0.336[4 N m^{-1}] (1) Repulsive force (or equivalent) (1)	1 1	1 1		4	3	
	(c)	(i)	Use of Bqv [i.e. $F = 2.15 \times 10^{-14}$ N] (1) $\frac{mv^2}{r}$ or $m\omega^2 r$ used (1) Radius calculated $r = 3.56$ c[m] or $F = 3.06 \times 10^{-14}$ [N] or $v = 2 \times 10^7$ [m s^{-1}] (1) Not circular or radius too large or field not uniform or force not large enough or speed too large (1)			4	4	2	
		(ii)	Starts in correct direction (1) Curving downward or clockwise (1)		2		2		
	(d)		Equation $F = Eq$ used (1) $F = Bqv$ used (1) Note $Eq = Bqv$ or $E = Bv$ scores both marks Substitution of $E = \frac{V}{d}$ (1) (use of $V = Bvd$ gets 3 marks) Final correct calculation(s) e.g. forces = $(2.15 \text{ \& } 2.16) \times 10^{-14}$ N or confirmation of V, B, v or d from the other values (1) Final conclusion consistent with answer ecf - true (accept not true because 2.15 different from 2.16) (1)			5	5	3	
			Question 4 total	**5**	**4**	**9**	**18**	**9**	**1**

#2

Question			Marking details		Marks available				
				AO1	AO2	AO3	Total	Maths	Prac
4	*(a)*		Valid method for obtaining gradient (implied if correct) (1) Max = ~0.021 or min = ~0.017 (1) [OK to give 21.0 & 17.5 mT A^{-1}] Mean correct (~0.019) (1) Uncertainty = 8.5 % – 11% (1) [no s.f. penalty]		4		4	4	4
	(b)		Gradient = $\mu_0 n$ used or implied (n =15 200) (1) N = 3 780 (1) N = 3 800 ± 400 (1) [allow 1 or 2 s.f. in uncertainty 1 more s.f. in N]			3	3	3	3
	(c)	(i)	5 000 is outside uncertainty range [or equiv.] (1) Straight line (1) Through all error bars (1) Lines straddle the origin (1) [allow ….through origin]			4	4		4
		(ii)	Flux density least accurate/probe not in centre [end effect] /not aligned [90° to axis](1) Get better Hall probe with higher [smaller / better] resolution / put in centre/align properly (1) [not: repeat readings / better apparatus]			2	2		2
			Question 4 total	**0**	**4**	**9**	**13**	**7**	**13**

#3

(a)		Valid complete statement - 2 marks e.g. Induced emf is proportional to (or equal to) the rate of change (or cutting) of flux (linkage). e.g. Accept induced emf = change of flux / time e.g. Accept emf = rate of flux cutting (bod - missing induced) Nearly complete statement - 1 mark e.g. $\mathcal{E} = [-]\frac{[d]\varphi}{[d]t}$ (terms not defined) e.g. Induced emf is proportional to change of flux (missing rate of)	2
(b)	(i)	$\mathcal{E} = -\frac{d\varphi}{dt}$ or $\frac{\varphi}{t}$ *or* $\frac{BA}{t}$ *or* $\frac{BAN}{t}$ (1) $A = \pi r^2$ used (1) Use of $I = \frac{V}{R}$ (1) Correct answer (1)	4
	(ii)	$\div \sqrt{2}$ (1) = 1410 [A] (1)	2
	(iii)	$P = IV$ or I^2R or V^2/R used (1) = 456 [W] (1)	2

#4

(a)

Either	**Or**
Flux changes (1) hence emf induced (1) [Because of RH rule or Faraday → 2nd mark, but not 1st mark] flux increases and decreases [implies 1st mark] [i.e. $\frac{d\Phi}{dt}$ alternates implied](1) NB. "Change in field" not 1st mark but others available]	B-lines being cut (1) hence emf induced (1) [Because of RH rule or Faraday → 2nd mark, but not 1st mark] direction of cutting changing (1) [Not "magnet oscillating" accept "magnet changing direction [of motion]"]

3

(b) (i) $V_{rms} = \frac{Vo}{\sqrt{2}} = 0.5\,\text{V}$ 1

(ii) Rate of change of flux (linkage) = 0.707 [V] (1)

from Faraday's [or Neuman's] law or $E = N\frac{d\Phi}{dt}$ [allow $E = \frac{\Phi}{t}$](1)

[Independent mark – must be stated]

For 1 turn = $\frac{0.707}{200} = 0.0035(35)\,\text{Wb s}^{-1}$ (1)

NB. 0.0025 Wb s^{-1} [from use of V = 0.5 V]→ 2 if 2nd mark awarded. 3

(c) Stating or implying that there is a magnetic field set up in the coil (1)
Opposes motion / due to Lenz's law (1)
Detail given, e.g. loss (dissipation) of energy due to current or resistance, polarity of coil discussed [can imply 1st mark], work done against resistive force (1) 3

[10]

#5

Question			Marking details	Marks Available
2	*(a)*	(i)	0	1
		(ii)	$\varphi = B \times l^2$ (1)	
			Answer = 4.32×10^{-5} [Wb] (1)	2
	(b)		Change in flux or Faraday's law gives emf (1)	
			Complete circuit or accept emf gives current (1) **Award 1 mark only for:** Current due to Faraday's law	2
	(c)		Force / current / emf **opposes the change** (1)	
			Force on PQ opposite to SR **or** the force is clockwise (1)	2
	(d)		$I = \frac{V}{R}$ used (1)	
			$A = \pi\frac{d^2}{4}$ *or* $\pi \times 3^2(\times 10^{-6})$ i.e. πr^2 used (1)	
			$R = \frac{\rho \times l}{A}$ used (1)	
			$V = \frac{\Delta N\phi}{\Delta t}$ used (1)	
			Answer = 0.19 [A] **ecf** on ϕ and πd^2 (1)	5
			Question 2 Total	**[12]**

#6

(a)		The [induced] emf is proportional [or equal] to the rate of change [or cutting] of flux [linkage] or d*BAN*/d*t* and terms defined Nearly correct statements award 1 out of 2 marks e.g. The emf is equal to the change of flux The current is **proportional** to the rate of change of flux The emf is proportional to the cutting of flux *BAN*/*t* and terms defined Wrong statements get 0 The emf is equal/proportional to the flux linkage The current is **equal** to the rate of change of flux	2
		Lenz - the [induced] emf [or current] opposes [or tends to oppose etc.] the change [to which it is due]	1
(b)	(i)	Clockwise (1) any 1 of FLHR(must have correct direction), FRHR, right hand grip rule (1)	2
	(ii)	Area increases ✓ at an increasing rate ✓ or cutting of flux ✓ inside the loop ✓ or $E=Blv$ ✓ and l is increasing ✓	2
	(iii)	$V = \frac{BAN}{t}$ and $t = \frac{20.1}{31} (= 0.648\ \text{s})$ or $E = Blv$ used (1) $A = \frac{1.8+2.9}{2} \times 20.1 [= 47.2]$ or mean $l = 2.35$ [m] (1) $I = \frac{V}{R}$ (1) Correct answer $I = 77$ [μA] (1)	4

#7

(a)	(i)	Flux linkage = $NBA\cos\theta$ used (1) 0.251 [Wb] [and 0.251 Wb] (1)	2
	(ii)	No change in flux [linkage] or field lines cut in one direction and then the opposite direction Don't accept rate of change of flux is 0	1
(b)		Flux linkage = 0.0443 or -0.0443 (1) Time = $\frac{20}{360} \times 0.1$ (1) Attempt at change of flux (linkage) divided by time (1) Answer = [-] 15.9 [V] (1)	4
(c)		Peak emf = 17 [V] Sinusoid with peak of 3.4 squares high (ecf) (1) Sinusoid with period of 4 squares (1)	3

#8

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
5	*(a)*	(i)	Use of BA = flux or Faraday's law $\Delta(BA)/t$ (1) [or by impl.] $\frac{2.1\times(610-120)\times10^{-4}}{0.016}$ seen (or similar) (1)	1	1		2	2	2
		(ii)	Anticlockwise (accept words if not in diagram) (1) FRHR or Right hand screw rule or FLHR on electrons (1) **Alternative (for explanation)** Lenz's law: [direction of induced flux must oppose so out of paper.]	1	1		2		2
	(b)		Resistance = $\frac{\rho l}{\pi r^2}$ quoted or used (0.0034 Ω) (1) Use of $I = \frac{V}{R}$ (1) $\frac{6.4\times\pi\times0.0015^2}{2.65\times10^{-8}\times0.91}$ [=1880 A] or equivalent seen (1)	1	1 1		3	3	3
	(c)		$V = \pi r^2 l$ used [= 6.43 × 10^{-6} m^3] (1) Mass = density × volume used [=0.0174 kg] (1) Energy = IVt used (or equivalent 195 J) (1) Energy = $mc\Delta T$ used (1) Answer = 12.5 K so lestyn wrong(1)			5	5	5	5
	(d)		Any 2 × (1) from • Consent of patient discussed [e.g. volunteers] (1) • possible injury to patient discussed [e.g. long-term effects] (1) • Appropriateness of experiment carried out on model / dead body / animal instead discussed (1) Conclusion Argument is logical and leads to a conclusion (even if a mixed conclusion) (1)			3	3		
			Question 5 total	3	4	8	15	10	12

#9

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
	(a)	(i)	Change in flux linkage or cutting flux (1) Complete circuit or implied (1)	2			2		
		(ii)	These are in the plane of motion/the vertical component is perpendicular to motion/these are not cut		1		1		
	(b)		Use of $\frac{BAN}{t}$ or $V = Blv$ (1) Use of $I = \frac{V}{R}$ (1) Answer = 62 μ[T] (1)	1 1	 1		 3	 3	
	(c)		Current down in resistor [or up in conductor or anticlockwise] (1) [F]RHR or [F]LHR (for electrons) or RH grip rule (1)	 1	1		 2		
	(d)		Other force compared e.g. friction/drag (1) Magnetic force small / resistive force is much bigger (1) Because current small / B small (1) Good calculation e.g. $P = I^2R = 8.8 \times 10^{-7}$ [W] **or** $F = BIL = 1.6 \times 10^{-8}$ [N] **ecf** on B **or** calculated values of B using I (1)			4	4	1	
			Question total	**5**	**3**	**4**	**12**	**4**	**0**

#10

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
5	(a)		[Induced] emf (or pd or voltage) equal to (or proportional to) the rate of change (or cutting) of flux [linkage] (1) The emf [tends to] oppose the change [to which it is due] (1)	2			2		
	(b)		**Indicative content:** Flux in pipe(s) changes or flux cut by pipe(s) Emf induced in pipe(s) Pipe P current cannot flow / incomplete circuit Pipe Q current flows [Current] opposes motion (change) …. …..(since) magnetic field set up due to (induced) current Uniform acceleration - no opposing force or gravity only **Additional useful points –** Terminal velocity - magnetic force equal (and opposite) to weight Slow velocity - due to strong magnet or small resistance or large current GPE converted to internal energy or electrical energy or electromagnetic energy Copper is not magnetic **5-6 marks** Comprehensive list of observations made. *There is a sustained line of reasoning which is coherent, relevant, substantiated and logically structured.* **3-4 marks** Some reasonable observations made. *There is a line of reasoning which is partially coherent, largely relevant, supported by some evidence and with some structure.* **1-2 marks** Limited observations made. *There is a basic line of reasoning which is not coherent, largely irrelevant, supported by limited evidence and with very little structure.* **0 marks** *No attempt made or no response worthy of credit.*		6		6		
	(c)		mgh **or** $mc\Delta\theta$ used **or** implied (i.e. $E_p = 2.35$ J) (1) Use of $V = Ah$ (1) Use of $m = \rho V$ (1) (i.e. $m = 0.056$ kg) Answer = 0.109 [K] (1)		 4		 4	 4	
			Question 5 total	**2**	**10**	**0**	**12**	**4**	**0**