Question	Answer		Mark
$1^{*}(a)$	(QWC – Work must be clear and organised in a logical manner		
	using technical wording where appropriate)		
	Max 6 from Reference to changing/outting of field/flux	(1)	
	Reference to changing/cutting of field/flux	(1)	
	Induced e.m.f. proportional to rate of change/cutting of flux		
	(linkage)	(1)	
	(accept equation)		
	Initial increase in e.m.f. as the magnet gets closer to the coil	(1)	
	Identifies region of negative gradient with magnet going		
	through the coil	(1)	
	Indication that magnet's speed increases as it falls	(1)	
	Negative (max) value > positive (max) value		
	(this mark is dependent on awarding marking point 5)	(1)	
	Time for second pulse shorter		
	(this mark is dependent on awarding marking point 5)	(1)	
	The areas of the two parts of the graph will be the same (since N $\phi$	(1)	
	constant)	(1)	6
1(h)	Two sequential pulses	(1)	
	(if <b>not</b> two sequential pulses, scores zero)	(-)	
	Pulses same height (+/- 3 mm squares) and width (by eye)	(1)	
	Pulses in opposite directions Region of zero e m f in the middle	( <b>1</b> )	4
		(1)	-
	Example (peaks could be in opposite directions)		
	Induced Te.m.f.		
	0 Distance		
	Total for question		10

1 runnedReference to magnetic flux (linkage)(1)2(a)Reference to magnetic flux (linkage)(1)Magnet vibrates/moves(1)Flux/field through the coil changes(1)Induces_emf / pd(1)2(b)(i)Use of $T = 2\pi/\omega$ for a revolution(1) $\omega = 3.5 \text{ rad s}^{-1}$ (1)Example of Calculation(1) $\omega = 33 \times 2\pi \text{ rad}/ 60 \text{ s}$ (1) $\omega = 3.5 \text{ rad s}^{-1}$ (1)2(b)(ii) $\omega / T / f \text{ remains constant}$ (1) $v = r\omega \text{ Or } C = 2\pi r$ (1)So as the stylus moves towards the centre(1)	Question Number	Answer	Mark
2(a)Reference to inlightly that (inlight)(1)Magnet vibrates/moves(1)Flux/field through the coil changes(1)Induces emf / pd(1)2(b)(i)Use of $T = 2\pi/\omega$ for a revolution(1) $\omega = 3.5 \text{ rad s}^{-1}$ (1)Example of Calculation(1) $\omega = 3.5 \text{ rad s}^{-1}$ (1)2(b)(ii) $\omega / T / f$ remains constant(1) $\nu = r\omega$ Or $C = 2\pi r$ (1)So as the stylus moves towards the centre(1)	2(a)	Reference to magnetic flux (linkage) (1)	
Integrate violates noves(1)Flux/field through the coil changes(1)Induces emf / pd(1)2(b)(i)Use of $T = 2\pi/\omega$ for a revolution $\omega = 3.5 \text{ rad s}^{-1}$ (1)Example of Calculation $\omega = 3.5 \text{ rad s}^{-1}$ 2(b)(ii) $\omega / T / f \text{ remains constant}$ $v = r\omega \text{ Or } C = 2 \pi r$ So as the stylus moves towards the centre	2(a)	Magnet vibrates/moves (1)	
Induces emf / pd(1)Induces emf / pd(1)2(b)(i)Use of $T = 2\pi/\omega$ for a revolution $\omega = 3.5 \text{ rad s}^{-1}$ (1) $Example of Calculation$ $\omega = 3.5 \text{ rad s}^{-1}$ 2(b)(i) $\omega / T / f \text{ remains constant}$ $v = r\omega \text{ Or } C = 2 \pi r$ So as the stylus moves towards the centreSo as the stylus moves towards the centre		Flux/field through the coil changes (1)	
Indices chill / pd(1)42(b)(i)Use of $T = 2\pi/\omega$ for a revolution(1) $\omega = 3.5 \text{ rad s}^{-1}$ (1) $Example of Calculation$ $\omega = 33 \times 2\pi \text{ rad/ } 60 \text{ s}$ $\omega = 3.5 \text{ rad s}^{-1}$ (1)2(b)(ii) $\omega / T / f$ remains constant $v = r\omega \text{ Or } C = 2\pi r$ 		Induces emf / nd (1)	4
2(b)(i)Use of $T = 2\pi/\omega$ for a revolution(1) $\omega = 3.5 \text{ rad s}^{-1}$ (1) $Example of Calculation$ $\omega = 33 \times 2\pi \text{ rad/ } 60 \text{ s}$ $\omega = 3.5 \text{ rad s}^{-1}$ (1)2(b)(ii) $\omega / T / f$ remains constant $v = r\omega \text{ Or } C = 2\pi r$ So as the stylus moves towards the centre stylus noves towards the centre stylus noves towards the centre(1)		<u>induces</u> chilly pu	-
$\omega = 3.5 \text{ rad s}^{-1}$ (1) 2 Example of Calculation $\omega = 33 \times 2\pi \text{ rad/ } 60 \text{ s}$ $\omega = 3.5 \text{ rad s}^{-1}$ 2(b)(ii) $\omega / T / f \text{ remains constant}$ (1) $v = r\omega \text{ Or } C = 2\pi r$ (1) So as the stylus moves towards the centre (1) $\omega = 1000 \text{ remains constant}$ (1)	2(b)(i)	Use of $T = 2\pi/\omega$ for a revolution (1)	
Example of Calculation $\omega = 33 \times 2\pi \text{ rad/ } 60 \text{ s}$ $\omega = 3.5 \text{ rad s}^{-1}$ (1)2(b)(ii) $\omega / T / f \text{ remains constant}$ $v = r \omega \text{ Or } C = 2\pi r$ 		$\omega = 3.5 \text{ rad s}^{-1} \tag{1}$	2
Example of Calculation $\omega = 33 \times 2\pi \text{ rad/ } 60 \text{ s}$ $\omega = 3.5 \text{ rad s}^{-1}$ (1)2(b)(ii) $\omega / T / f \text{ remains constant}$ $v = r \omega \text{ Or } C = 2\pi r$ So as the stylus moves towards the centre (1)(1)			
$\omega = 33 \times 2\pi \text{ rad/ } 60 \text{ s}$ $\omega = 3.5 \text{ rad s}^{-1}$ 2(b)(ii) $\omega / T / f \text{ remains constant}$ $v = r\omega \text{ Or } C = 2\pi r$ So as the stylus moves towards the centre		Example of Calculation	
$\omega = 3.5 \text{ rad s}^{-1}$ 2(b)(ii) $\omega / T / f \text{ remains constant}$ $v = r\omega \text{ Or } C = 2 \pi r$ So as the stylus moves towards the centre		$\omega = 33 \times 2\pi \text{ rad}/60 \text{ s}$	
$2(b)(ii)$ $\omega / T / f$ remains constant(1) $v = r \omega$ Or $C = 2 \pi r$ (1)So as the stylus moves towards the centre(1)		$\omega = 3.5 \text{ rad s}^{-1}$	
$\omega / T / f \text{ remains constant} $ (1) $v = r\omega \text{ Or } C = 2 \pi r $ (1) So as the stylus moves towards the centre	2(b)(ii)		
$v = r\omega \text{ Or } C = 2 \pi r $ So as the stylus moves towards the centre $(1)$		$\omega / T / f$ remains constant (1)	
$v = r\omega \text{ Or } C = 2 \pi r $ So as the stylus moves towards the centre $(1)$			
So as the stylus moves towards the centre		$v = r\omega \operatorname{Or} C = 2 \pi r \tag{1}$	
So as the stylus moves towards the centre			
		So as the stylus moves towards the centre	
(tangential/linear) speed/velocity <b>Or</b> path length (per rotation)		(tangential/linear) speed/velocity <b>Or</b> path length (per rotation)	
gets less (1) 3		gets less (1)	3
Total for question 9		Total for question	9

Question	Answer	Mark
Number		
<b>3</b> (a)	Indication of vertical force(s) on sides AB or CD (1)	
	[up or down is equivalent to vertical]	
	Opposite vertical forces on AB and CD (	
	Indication of anticlockwise rotation (1)	4
	[Allow full credit for a written description]	
	(Commutator) switches current direction (1)	
3(b)*	(QWC – Work must be clear and organised in a logical manner using technical wording where appropriate)	
	$\frac{Flux}{Flux} (linkage) changes / flux is cut (1)$	
	Mention of <u>induced</u> e.m.f [allow induced voltage] (1)	
	E.m.f increases with speed (1)	
	Mention of Lenz's Law (1)	Max 4
	(e.m.f./voltage) opposes current [not "reduces"] (1)	
	Total for question	8

Question	Answer	Mark
Number		
<b>4</b> (a)	Force on (charged) particles at right angles to motion (1)	
	Causes circular motion [not spiral / curved]	-
	OR force/acceleration is centripetal (1)	2
	[credit first mark if clear from diagram]	
4(b)(i)	Momentum: $p=mv$ or $r = mv/Be$ (1)	
	$v = 2\pi r/T$ or $v = r\omega$ or $\omega = Be/m$ (1)	
	Use of $f = 1/T$ or $\omega/2\pi$ (1)	3
	[allow $q$ for $e$ ]	
	Example of calculation	
	Ber = mv	
	$Ber = m2\pi r/T$	
	$Be = m2\pi f$	
4(b)(ii)	(Protons) accelerated / given energy,	
	in the gaps / between D's/from one D to the other (1)	2
	Every half rotation/semicircle later	
	(polarity of D's) needs a change (1)	
4(b)(iii)	Relativistic effect / $v$ approaching $c$ /mass increases (1)	
	so frequency decreases (1)	2
	[second mark consequent on first]	
4(c)	must be accelerating due to circular motion (1)	
	(Speed constant but) direction/velocity changing (1)	2
	Total for question	11

Question	Answer	Mark
Number		
5	Current in coil generates magnetic field (1)	
	Current drops/decreases (1)	
	Change of flux [accept flux cut] (1)	
	Rapid/quick/short time (1)	
	Large emf/200 V induced(1)	
	Field/flux linkage large due to many turns (1)	4 max.
	Total for question	4