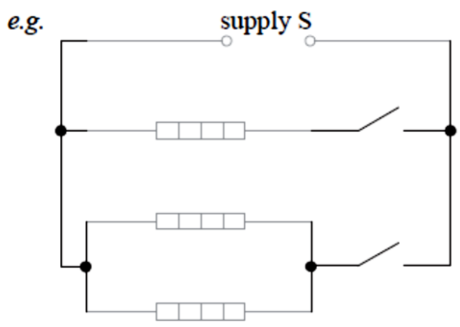
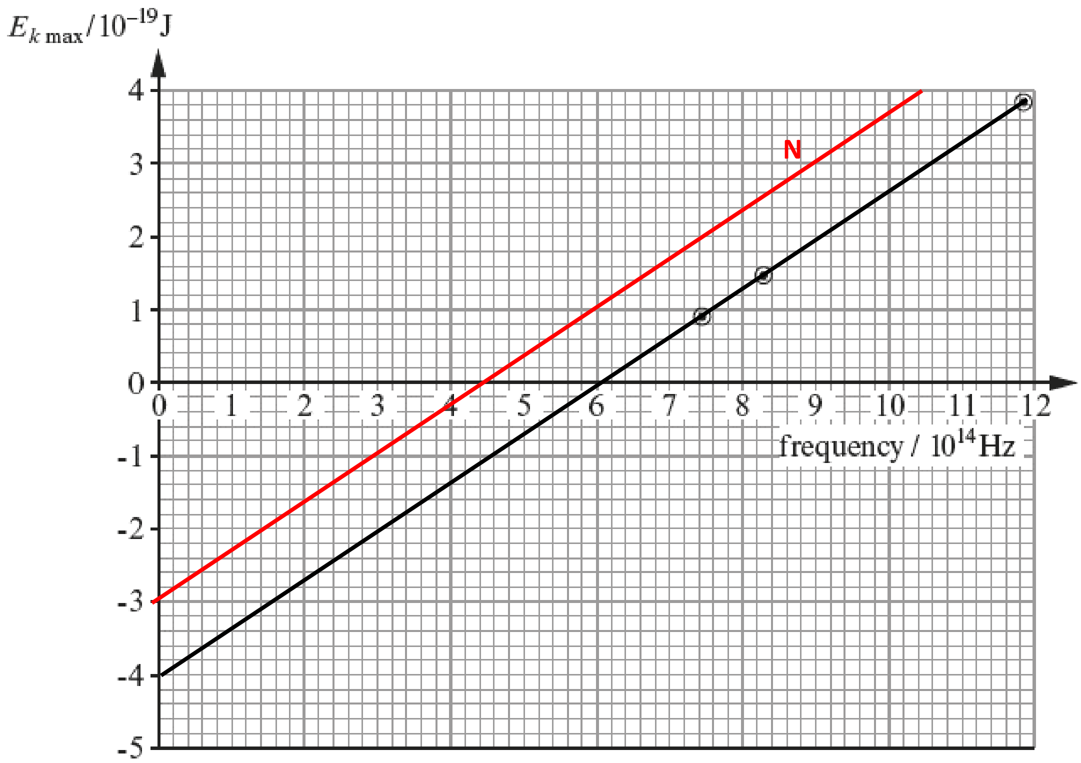
HCI 2016 C2 H1 Prelim Physics Paper 2 Suggested Solution

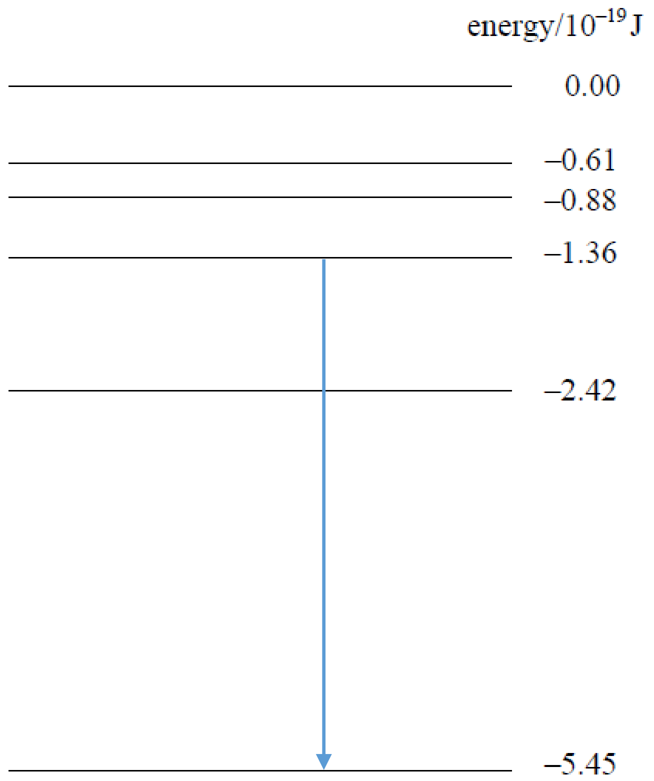
1	**(a)**	**(i)**	Area under graph between 0.5 and 1.0 s OR Use average velocity between these points multiply by time	**B1**
		(ii)	Gradient of line at Y at 1.0 s	**B1**
		(iii)	Velocity has both positive and negative values on graph which shows that the quantity can be represented in 2 directions (i.e. upwards and downwards), hence a vector.	**B1**
		(iv)	Δu = smallest half division from graph = 0.2 m s^{-1}	**A1**
	(b)	**(i)** **(ii)**	**(Accept one error with correct explanations)** The 2 non vertical lines are not parallel As acceleration should be same hence same gradient OR Maximum positive and negative speeds at 0.5s are the same There will be some energy losses during bounce (or air resistance), so maximum values of velocity at bounce should have smaller magnitude each time. OR Velocity at X or Z is greater than at the start Ball cannot gain energy, hence velocities at X or Z should get progressively smaller OR Starts with a positive velocity But initial movement is downwards. OR Starts with non-zero velocity or graph starts in wrong position From photo, it is dropped from rest. OR There is vertical line at bounce (X) Bounce must take some time or acceleration can't be infinite. OR Graph shows a change in direction of velocity between 0 and 0.5 s (from release to striking the ground) It is travelling in one direction or down this whole time. OR Graph shows an initial deceleration But the ball is actually accelerating downwards.	 **B1** **B1**

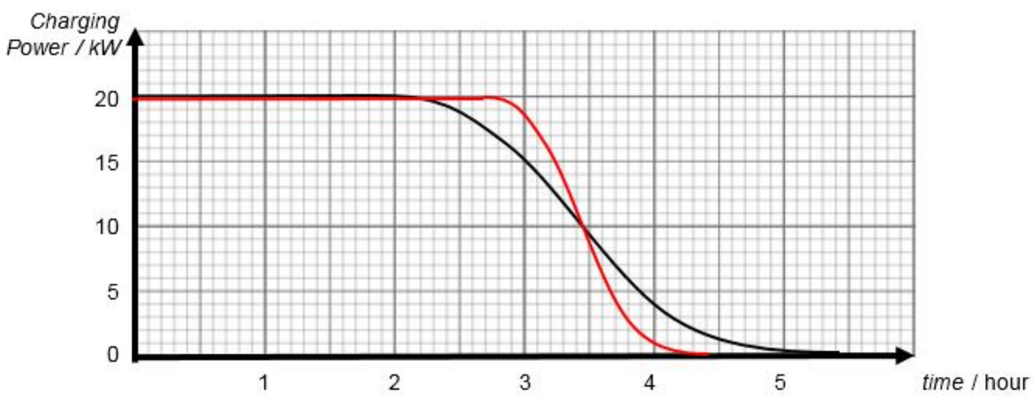
2	**(a)**	(i)	$\Delta p = m(v-u) = 0.035(3.5-(-4.5)) = 0.28$ N s $F = \dfrac{\Delta p}{\Delta t} = \dfrac{0.28}{0.14} = 2.0$ N Direction : upwards	**M1** **A1** **B1**
		(ii)	Loss in KE = $\dfrac{1}{2}(0.035)(4.5^2 - 3.5^2) = 0.14$ J	**C1** **A1**
	(b)		Consider the ball and the plate (and Earth) as a system. Since the forces of interaction between the ball and the plate are action reaction forces, the momentum lost by the ball will be gained by the plate. Hence the net momentum of the system is still conserved.	**B1** **M1** **A1**

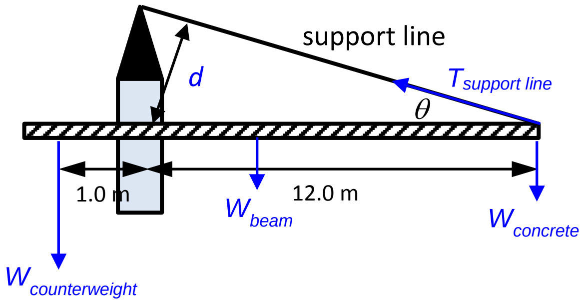
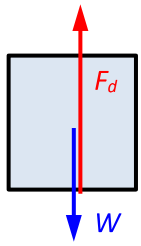
3	**(a)**	$R = \dfrac{\rho L}{A} \Rightarrow \dfrac{V^2}{P} = \dfrac{4\rho L}{\pi d^2}$ $L = \dfrac{\pi d^2 V^2}{4\rho P} = \dfrac{\pi(3.5\times10^{-4})^2(230^2)}{4(1.3\times10^{-6})(980)} = 3.99 \approx 4.0$ m	**M2** **C1**
	(b)	 switch connected so that *P* can be achieved; another switch connected so that 2*P* and 3*P* can be achieved; *Award **[0]** if three or more switches used. Allow any correct alternative including case where single resistor is permanently connected to supply. There are many variants, this diagram is only one example.*	**A2**

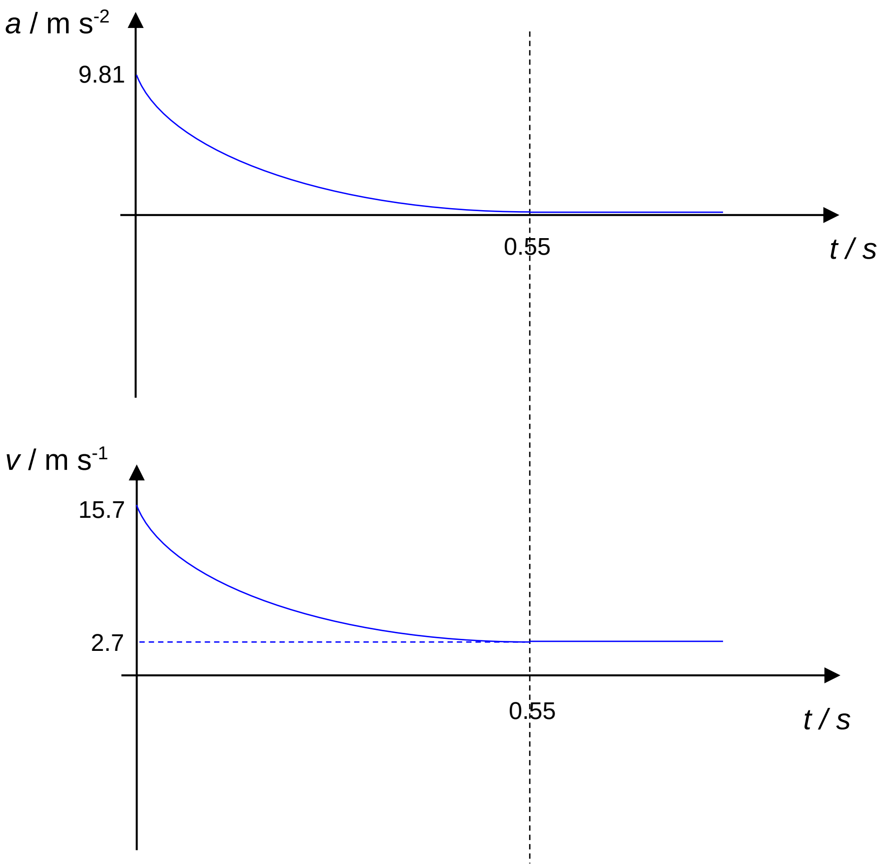
4	**(a)**	$E_{K\max} = hf - \phi$ Hence, h = gradient of graph $= \dfrac{3.8-(-3.6)}{11.2-0.6} \times \dfrac{10^{-19}}{10^{14}}$ $= 6.98 \times 10^{-34}$ J s Accept values [6.3×10^{-34} to 7.6×10^{-34} J s] [M1]- Drawing line of best fit and using 2 appropriate points to calculate gradient [A1] – Answer mark [-1] – if gradient working is unclear or if two points chosen are not more than ½ the length of the BFL	**M1** **A1**

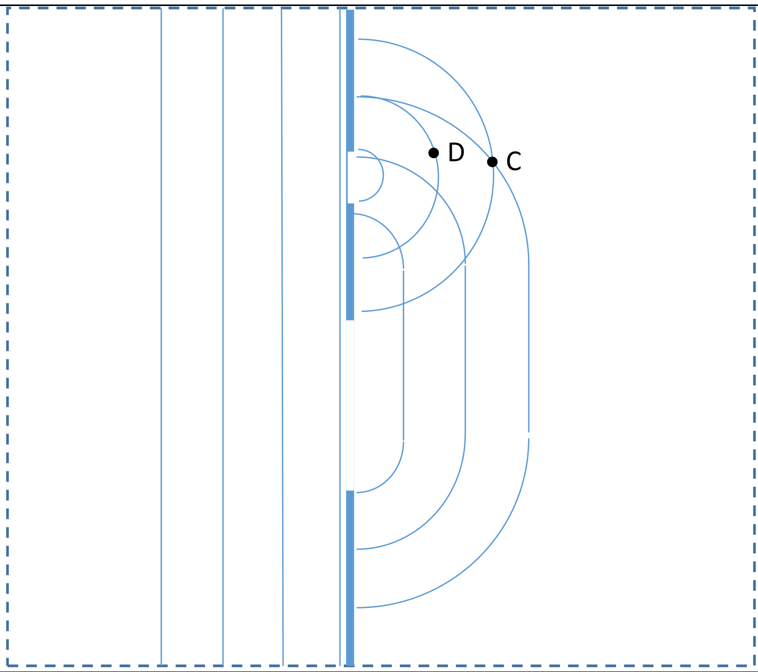
	(b)	$\phi = \lvert \text{Vertical intercept of the graph} \rvert$ $= 4.0 \times 10^{-19}$ J $= \dfrac{4.0 \times 10^{-19}}{1.60 \times 10^{-19}}$ eV = 2.5 eV **OR** **Using *h* value above with threshold frequency read from graph:** $\phi = hf_o = (6.98 \times 10^{-34})(6.1 \times 10^{14})$ $= 4.26 \times 10^{-19}$ J $= \dfrac{4.26 \times 10^{-19}}{1.60 \times 10^{-19}}$ eV = 2.66 eV ~ 2.5 eV **OR** **Using *h* value from constant list with threshold frequency read from the graph:** $\phi = hf_o = (6.63 \times 10^{-34})(6.1 \times 10^{14})$ $= 4.04 \times 10^{-19}$ J $= \dfrac{4.04 \times 10^{-19}}{1.60 \times 10^{-19}}$ eV = 2.53 eV ~ 2.5 eV The metal is barium. (Ans)	**M1** **A1**
	(c)	 A straight line graph parallel to the original graph and with a larger vertical intercept. Vertical intercept must still be negative.	**A1**

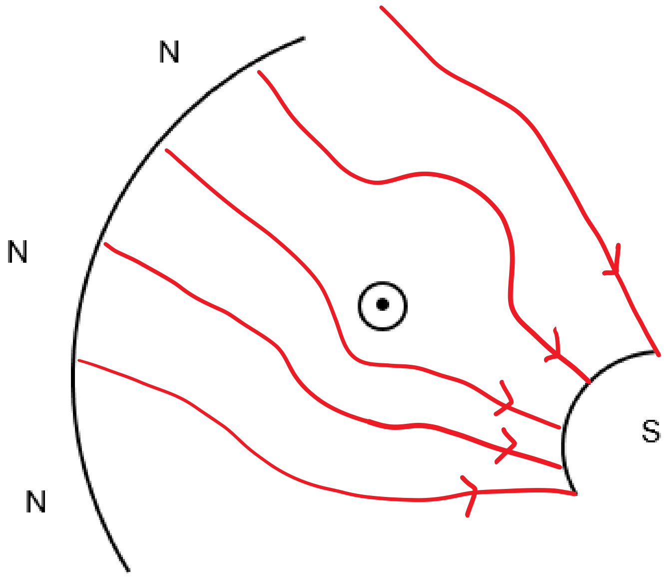
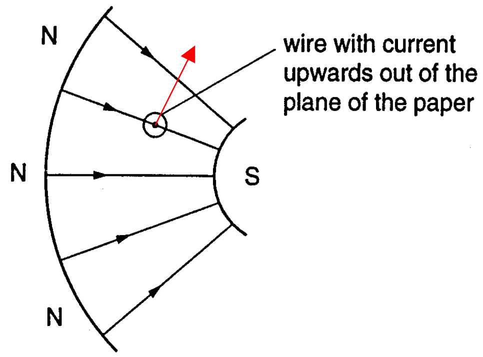
5	**(a)**	$E = h\dfrac{c}{\lambda} = \dfrac{(6.63\times10^{-34})(3.00\times10^{8})}{(486\times10^{-9})}$ $= 4.09\times10^{-19}$ J $\sim 4\times10^{-19}$ J (Shown)	**M1**
	(b)	An excited hydrogen atom **can only occupy any one of the energy levels higher than the lowest energy level (ground state)** but not between the energy levels. When it **de-excites, it drops from this higher energy level to a lower energy level emitting a photon with wavelength/energy corresponding to the difference in the energy levels.** Since the **energy levels are discrete**, **only certain wavelengths of the photons are produced during de-excitation**, producing the line spectral shown in Fig. 5.1.	**B1** **B1** **B1**
	(c)	 Vertical arrow pointing from -1.36 to -5.45 x 10^{-19} J. [5.45 x 10^{-19} – 1.36 x 10^{-19} = 4.09 x 10^{-19} J]	**A1**

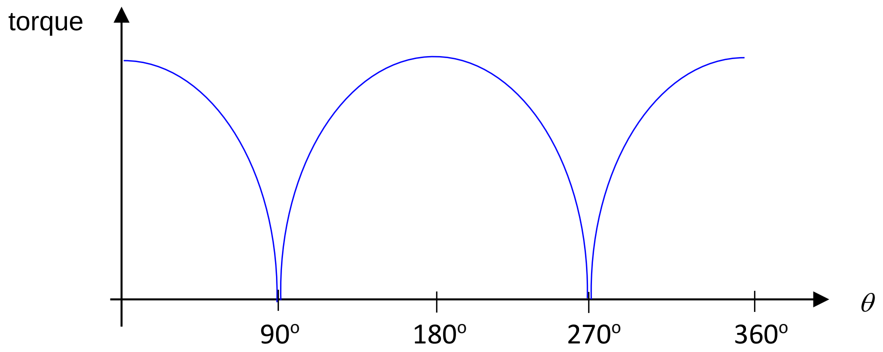
6	(a)	(i)	Energy stored = $23 \times 1000 \times 3600 = 8.28 \times 10^7$ J	M1
		(ii)	Average energy expenditure per kilometer = $\frac{8.28 \times 10^7}{122} = 6.79 \times 10^5$ J km^{-1} = 679 kJ km^{-1}	M1 A1
		(iii)	Classic model's energy expenditure per kilometre = $\frac{9.7 \times 1000 \times 3600}{29.1} = 1200$ kJ km^{-1}	M1 A1
	(b)		$\text{Cost saving} = \left(\frac{20{,}000}{29.1} \times 0.9221\right) - \left(\frac{20{,}000}{122} \times 23 \times 0.1044\right) = \$240$	M1 A1
	(c)	(i)	Capacity $=$ *area under graph* $= \left[(20 \times 2) + \frac{1}{2}(20)(3)\right] = 70$ kWh OR $= \left[(20 \times 2) + \frac{1}{2}(20+17+3)(1) + \frac{1}{2}(3)(1)\right] = 66.5$ kWh (Accept answers between 66.5 – 70 kWh; if answer outside of that range then no answer mark)	M2 A1
		(ii)	 Same area under graph ➔ taper later but end earlier	B1

7	**(a)**	(i)	The net force acting on the body is zero. The net moment about any point is zero.	**B1** **B1**
		(ii)	 tan θ = 3.0/12.0 ➔ θ = tan^{-1} (3.0/12.0) = 14.036º sin θ = d/12.0 ➔ d = 12.0 sin θ = 12.0 sin 14.036º = 2.9104 m Taking moments about the joint, Sum of clockwise moments = sum of anticlockwise moments $(W_{concrete})(12.0) + (W_{beam})(4.0) = (W_{counterweight})(1.0) + (T_{support\ line})d$ T = 104 000 N = 104 kN	**M1** **M1** **A1**
	(b)		Taking downwards as positive, $v^2 = u^2 + 2as$ $\Rightarrow v = \sqrt{1^2 + 2(9.81)(13.5)} = 15.7 \text{ m s}^{-1}$ Assumption: negligible air resistance	**M1** **C1** **A0** **B1**
	(c)	(i)	F_d = drag acting on the concrete block W = weight of the concrete block All arrows should be drawn with correct directions and correct points of origination and should be labelled correctly. The length of F_d should be longer than length of W.  	**A2**
		(ii)	Applying Newton's second law: $\sum F = ma$ $F_d - mg = ma$ $a = g - \frac{F_d}{m}$ $= g - \frac{kAv^2}{V\rho}$ $= g - \frac{kAv^2}{\rho A^{3/2}}$ $= g - \frac{kv^2}{\rho A^{1/2}}$	**M1** **B1** **B1** **A0**

		(iii)	Terminal velocity indicates that the acceleration is zero. From the equation above, $\frac{kv_T^2}{\rho A^{1/2}} = g$ $v_T = \left(\frac{\rho g}{k}\right)^{1/2} A^{1/4}$	**B1** **A1**
		(iv)	 B1 + B1: labelled axes for both graphs A1: correct shape for a-t graph A2: correct shape for v-t graph	**B2** **A3**

8	(a)	(i)	The single slit provides a point source of light. This ensures a constant phase difference between light that reaches either of the slits.	B1 B1
		(ii)	1. path difference = 2λ 2. phase difference = 4π rad	A1 A1
		(iii)	Fringe separation, $\Delta y = \frac{\lambda D}{d}$ $y = 2\Delta y = \frac{2\lambda D}{d}$	A1
		(iv)	$y = \frac{2\lambda D}{d}$ Hence $\lambda = \frac{yd}{2D} = \frac{(15\times10^{-3})(0.45\times10^{-3})}{2(6.15)} = 5.48 \times 10^{-7} m$	M1 A1
		(v)	Green	A1
		(vi)	New intensity is ¼ of the original intensity.	A1
	(b)	1.	Contrast becomes poorer. No change in the fringe separation.	A1 A1
		2.	No change in the fringe separation. The zero order maxima/whole pattern is shifted downwards.	A1 A1
		3.	Smaller fringe separation below O and larger fringe separation above O. Fringes get wider as the distance from the screen increases.	A1 A1
	(d)		 	
		(i)	- Same wavelength - For small hole, circular wavefront - For large hole, straight wavefront with circular edge	A1 A1 A1
		(ii)	Correct labelling of C Correct labelling of D	A1 A1

9	(a)	(i)	The magnetic flux density is defined as the force per unit length per unit current acting on an infinitely long current carrying conductor placed perpendicularly to the magnetic field. Mark by deduction	B2
		(ii)	Units of B = Units of $\frac{F}{IL}$ = kg m s^{-2} A^{-1}m^{-1} = kg s^{-2} A^{-1}	M1 A1
	(b)	(i)	 • distance between field lines are closer below and further above the wire • field lines are in the correct direction • field lines are curved with "bulge" at the upper region	B1 B1 B1
		(ii)	 The direction of the magnetic force is perpendicular to the current and magnetic flux density, as given by the Fleming's left hand rule.	A1
	(c)	(i)	W: vertically upwards; X: vertically downwards	A1
		(ii)	Moment of a force about a **point** (the pivot) is the **product (**of the magnitude) **of the force** and the **perpendicular distance of the line of action of the force to the point.** A couple always consists **of two parallel forces which are equal in magnitude and opposite in direction** (their lines of action do not coincide). Torque of a couple is the **product of the magnitude of one of the forces of the couple** and the **perpendicular distance between the forces**.	A1 A1 A1
		(iii)	The magnetic force on WY and XZ along the vertical and form a couple. Torque of couple =F_B x perpendicular distance between them $= [BI(WZ)](WX\cos\theta) = BIPQ\cos\theta$	M1 A1

		(iv)	 • Correct shape • Positive only	**B1** **B1**
		(v)	The <u>torque</u> on the frame due to the radial field is a <u>constant</u>, resulting in a smoother rotation of the frame at <u>constant angular acceleration.</u>	**A2**
	(d)	Advantage: larger magnetic force results in larger torque Disadvantage: joule heating resulting in loss of energy or inefficiency		**A1** **A1**