Electromagnetic Induction

Mark Scheme 3

Level	International A Level
Subject	Physics
Exam Board	CIE
Topic	Electromagnetic Induction
Sub Topic	
Paper Type	Theory
Booklet	Mark Scheme 3

Time Allowed: **77 minutes**

Score: **/64**

Percentage: **/100**

A*	A	B	C	D	E	U
>85%	'77.5%	70%	62.5%	57.5%	45%	<45%

1	**(a)**	**(i)**	(induced) e.m.f proportional/equal to rate of change of flux (linkage) *(allow 'induced voltage, induced p.d.)* flux is cust as the disc moves hence inducing an e.m.f	B1 M1 A0	[2]
		(ii)	field in disc is not uniform/rate of cutting not same/speed of disc not same (over whole disc) so different e.m.f.'s in different parts of disc lead to eddy currents	B1 M1 A0	[2]
	(b)		eddy currents dissipate thermal energy in disc energy derived from oscillation of disc energy of disc depends on amplitude of oscillations	B1 B1 B1	[3]

2	**(a)**		(numerically equal to) force per unit length ……………………………… on straight conductor carrying unit current ……………………………. normal to the field ………………………………………………………	M1 A1 A1	**[3]**
	(b)		flux through coil = $BA \sin\theta$ ……………………………………………….. flux linkage = $BAN \sin\theta$ ………………………………………………………	 B1	**[2]**
	(c)	**(i)**	(induced) e.m.f. proportional to ………………………………………. rate of change of flux (linkage) …………………………………………….	M1 A1	**[2]**
		(ii)	graph: two square sections in correct positions, zero elsewhere ….. pulses in opposite directions ……………………………………. amplitude of second about twice amplitude of first …………..	B1 B1 B1	**[3]**

3	**(a)**	**(i)**	50 mT	1	
		(ii)	flux linkage = *BAN*	1	
			= $50 \times 10^{-3} \times 0.4 \times 10^{-4} \times 150 = 3.0 \times 10^{-4}$ Wb	1	**[3]**
			(allow 49 mT→ 2.94×10^{-4} Wb or 51 mT→ 3.06×10^{-4} Wb)		
	(b)		e.m.f./induced voltage *(do not allow current)*		
			proportional/equal to	1	
			rate of change/cutting of flux (linkage)	1	**[2]**
	(c)	**(i)**	new flux linkage = $8.0 \times 10^{-3} \times 0.4 \times 10^{-4} \times 150$		
			= 4.8×10^{-5} Wb	1	
			change = 2.52×10^{-4} Wb	1	**[2]**
		(ii)	e.m.f. = $(2.52 \times 10^{-4})/0.30$	1	
			= 8.4×10^{-4} V	1	**[2]**
	(d)	*either*	for *a* small change in distance *x*	1	
			(change in) flux linkage decreases as distance increases	1	
			so speed must increase to keep rate of change constant	1	**[3]**
		or	(change in) flux linkage decreases as distance increases	(1)	
			at constant speed, e.m.f/flux linkage decreases as x increases	(1)	
			so increase speed to keep rate constant	(1)	

4 **(a)** field producing force of 1.0 N m^{-1} on wire *OR* $B = F/IL\sin 2$...........M1
carrying current of 1.0 A normal to field *OR* symbols explained ... A1 [2]

(b) **(i)** ϕ = *BA*
= $1.8 \times 10^{-4} \times 0.60 \times 0.85$ C1
= 9.18×10^{-5} Wb .... A1 [2]

(ii) $\Delta\phi = 9.18 \times 10^{-5}$ Wb... A1

(ii) $e = (N\Delta\phi)/\Delta t$
= $(9.18 \times 10^{-5})/0.20$ C1
= 4.59×10^{-4} V .... A1 [3]

(iii) there is an e.m.f. and a complete circuit
OR no resultant e.m.f. from other three sides
OR no e.m.f. in AB so yes... B1 [1]

5 (a) (i) the wire cuts magnetic field B1
e.m.f. induced when there is a change/cutting of flux B1
(ii) {Lenz) e.m.f. 'opposes' change causing it B1
as direction of movement changes, so does e.m.f. .... B1 [4]

(b) x_0 = 15 mV ..• (allow ±0.1).. C1
m = 2lt / T = 21tl {3 x 10^3) C1
= 2090 rad s^{-1} C1
x = 15 sin2090t .... A1 [4]

6	(a)	(i)	to concentrate the (magnetic) flux / reduce flux losses	B1	[1]
		(ii)	changing flux (in core) induces current in core	M1	
			currents in core give rise to a heating effect	A1	[2]
	(b)	(i)	e.m.f. induced proportional to	M1	
			rate of change of (magnetic) flux (linkage)	A1	[2]
		(ii)	magnetic flux in phase with / proportional to e.m.f. / current in primary coil	M1	
			e.m.f. / p.d. across secondary proportional to rate of change of flux	M1	
			so e.m.f. of supply not in phase with p.d. across secondary	A0	[2]
	(c)	(i)	for same power (transmission), high voltage with low current	B1	
			with low current, less energy losses in transmission cables	B1	[2]
		(ii)	voltage is easily / efficiently changed	B1	[1]

7	**(a)**	**(i)**	flux/field in core must be changing	**M1**	
			so that an e.m.f./current is induced in the secondary	**A1**	**[2]**
		(ii)	power = VI	**M1**	
			<u>output</u> power is constant so if V_S increases, I_S decreases	**A1**	[2]
	(b)	**(**	same shape and phase as I_P graph	**B1**	**[1]**
		(ii)	same frequency	**M1**	
			correct phase w.r.t. Fig. 6.3	**A1**	[2]
		(iii)	½π <u>rad</u> or 90°	**B1**	[1]