(F)

CERTIFICATE
OF SIXTH YEAR
STUDIES
1997

PHYSICS SY
DETAILED MARKING INSTRUCTIONS

STRICTLY CONFIDENTIAL

You must regard these **instructions** as **strictly confidential** and, in common with the scripts entrusted to you for marking, they must not form the subject of remark of any kind, except to the Scottish Qualifications Authority. **Similarly, the contents of these instructions must not be divulged now, or at any future time, to any other person.**

Markers' Meeting

You should use the time before the meeting to make yourself familiar with the question paper, instructions and any scripts which you have received. Do **not** undertake any final approach to marking until **after** the meeting. Please note any point of difficulty for discussion at the meeting.

Note: These instructions can be considered as final only after the markers' meeting when the full marking team has had an opportunity to discuss and finalise the document in the light of a wider range of candidates' responses.

Marking

The utmost care must be taken when entering and totalling marks. Where appropriate, all summations for totals must be carefully checked and confirmed.

Where a candidate has scored zero marks for any question attempted, "0" should be entered against the answer.

Recording of Marks

The mark for each **question**, where appropriate, should be entered on the grid provided on the back page of the answer book..

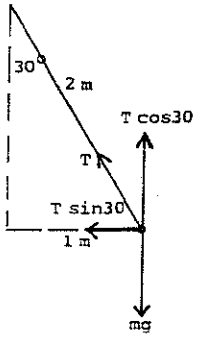
The **Total** mark for each paper should be entered in the box provided in the top-right corner of the front cover of the answer book

Always enter the **Total** mark (using red ink) as a **whole number**, where necessary by the process of rounding up.

The transcription of marks, within scripts and to Forms Sy6, should always be checked.

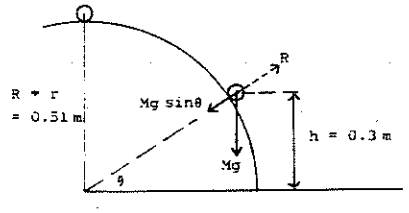
97miphys.sy

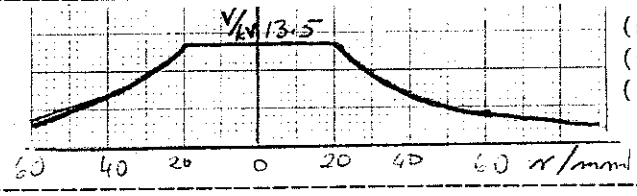
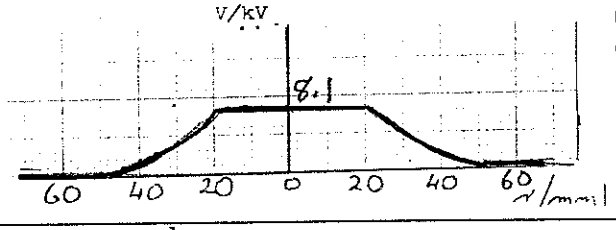
15 May 1997

	Sample answer and mark allocation	Notes	Marks	
1 (a)	$s = 24t - 2t^3$ $v = \frac{ds}{dt} = 24 - 6t^2$ (½) $v = 0$ when $6t^2 = 24$ (½) Time after start = $\underline{2\ s}$ (1)		2	
(b)	$a = \frac{dv}{dt} = -12t$ At $t = 2$, $a = \underline{-24\ ms^{-2}}$ (1)		1	
(c)	$s = 24 \times 2 - 2 \times 8 = \underline{32\ m}$ (1)		1	4
2 (a)	 Horizontally:– $T \sin 30 = m\omega^2 r$ (1) Vertically:– $T \cos 30 = mg$ (1) Dividing 1st by 2nd equation $\frac{\sin 30}{\cos 30} = \frac{m\omega^2 r}{mg}$ (½) $\omega^2 = \frac{g \tan 30}{r} = \frac{9.8 \times 0.577}{3}$ $\omega = 1.37$ (rad s^{-1}) (½) Period $T = \frac{1}{f} = \frac{2\pi}{\omega} = \underline{4.58\ s}$ (1)	For resolution, in diagram or statement $T \sin 30$ (½) $T \cos 30$ (½)	4	
(b)	No (½) As above at angle θ $\tan\theta = \frac{\omega^2 r}{g}$ does not involve m (1) (½)		2	6

	Sample answer and mark allocation	Notes	Marks	
3 (a)	$V = \frac{Q}{4\pi\varepsilon_0 r}$ (½) $= \frac{4 \times 10^{-6}}{4\pi \times 8.85 \times 10^{-12} \times 0.5}$ (½) $= \underline{71.9\ kV}$ (1)		2	
(b)	Work done = QV (½) $= 2 \times 10^{-6} \times 72 \times 10^{3}$ (½) $= \underline{0.14\ J}$ (1)		2	
(c)	Potential at C $= 71.9 + \frac{2 \times 10^{-6}}{4\pi \times 8.85 \times 10^{-12} \times 0.8}$ $= 71.9 + 22.5$ $= 94.4$ (kV) (1)	22.5 (kV) (½)		
	W.D. to add charge at C = QV $= -3 \times 10^{-6} \times 94.4 \times 10^{3}$ $= -0.283$ (J) (½)			
	Total energy required $= 0.144 - 0.283 = \underline{-0.14\ J}$ (½)		2	6
4	Force on electrons is <u>constant</u> (½) always at <u>right angles</u> to path (½) i.e. force is <u>radial</u> (½) towards a <u>central point</u> (½)		2	2
5 (a)	Force due to magnetic field is at <u>right angles to field</u>. (½) Force due to electric field is <u>in plane of field</u>. (½) Hence forces can <u>cancel</u>.		1	
(b)	$E = \frac{V}{d} = \frac{440}{40 \times 10^{-3}} = 1.1 \times 10^{4}$ (½) QvB = EQ (½) $v = \frac{E}{B} = \frac{1.1 \times 10^{4}}{3.8 \times 10^{-4}}$ $= \underline{2.9 \times 10^{7}\ ms^{-1}}$ (1)		2	
(c)	E_p lost = E_k gained $QV = \frac{1}{2}mv^2$ (½) $e/m = \frac{v^2}{2V} = \frac{(2.9 \times 10^{7})^2}{2 \times 2.5 \times 10^{3}}$ (½) $= \underline{1.68 \times 10^{11}\ Ckg^{-1}}$ (1)		2	5

	Sample answer and mark allocation	Notes	Marks	
6 (a)	Amplitude modulation wave	Frequency constant	1	
(b)	Displacement: sine wave (1) Velocity: cosine wave (1) Acceleration: -sine wave (1)		3	4
7 (a)	$y = a \sin 2\pi(ft + x/\lambda)$		1	
(b) (i)	Adding $y = a \sin 2\pi(ft + x/\lambda)$ and $y = a \sin 2\pi(ft - x/\lambda)$ gives $y = 2a \cos 2\pi x/\lambda \sin 2\pi ft$	must show some 'working'	1	
(ii)	Amplitude $2a \cos 2\pi x/\lambda$ depends on x but not t		1	
(iii)	Amplitude is zero when $2\pi x/\lambda = \pi/2$ or $3\pi/2$ ($\frac{1}{2}$) i.e. when $x = \lambda/4$ or $3\lambda/4$ ($\frac{1}{2}$) which are separated by $\lambda/2$		1	4
8	Longest wavelength from least energy change: Balmer 3 to 2 $E_n = \frac{-1}{n^2} \times 2.16 \times 10^{-19}$ $E_3 = -2.4 \times 10^{-19}$ (J) (1) $E_2 = -5.4 \times 10^{-19}$ (J) (1) $E = E_3 - E_2 = 3.0 \times 10^{-19}$ (J) ($\frac{1}{2}$) $E = hf$, $f = \frac{E}{h} = 4.54 \times 10^{14}$ ($\frac{1}{2}$) $v = f\lambda$, $\lambda = \frac{c}{f} = \underline{6.61 \times 10^{-7}\ m}$ (1)	Wrong transition Maximum 3 out of 4	4	4

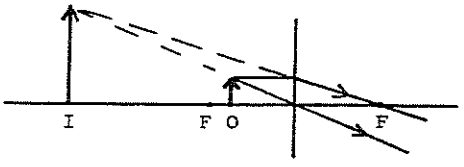
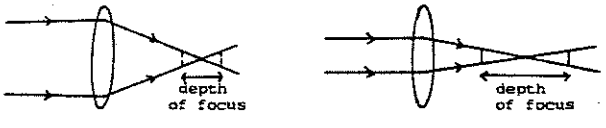
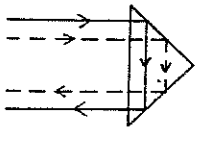
	Sample answer and mark allocation	Notes	Marks	
9 (a)	$\theta = \int_{(\frac{1}{2})} \omega dt = \int_{(\frac{1}{2})} (\omega_o + \alpha t) dt$ $= \omega_o t + \frac{1}{2}\alpha t^2 + k$ $(\frac{1}{2}) \quad (\frac{1}{2})$ When $t = 0$, $\theta = 0$ hence $k = 0$ $(\frac{1}{2}) \quad (\frac{1}{2})$ Therefore $\theta = \omega_o t + \frac{1}{2}\alpha t^2$		3	3
(b) (i)	E_p in earth's field $= -\frac{GMm}{r}$ $(\frac{1}{2})$ E_p of 2 kg at height of 600 km $= -\frac{6.67 \times 10^{11} \times 6 \times 10^{24} \times 2}{7 \times 10^6}$ $(\frac{1}{2})$ $(\frac{1}{2})$ $= \underline{-1.14 \times 10^8 \text{ J}}$ (1)	Must be negative		
(ii)	$\frac{1}{2}mv^2 = 1.14 \times 10^8$ $(\frac{1}{2})$ $v^2 = 1.14 \times 10^8 \times 2/2$ $v = \underline{1.07 \times 10^4 \text{ ms}^{-1}}$ (1)	or 10.7 kms^{-1}	4	4
(c) (i)	 Loss of $E_p = 0.21Mg$ (1) $E_k = \frac{1}{2}I\omega^2 + \frac{1}{2}mv^2 = E_p$ $(\frac{1}{2})$ $\frac{1}{2}.\frac{2}{5}.Mr^2.\frac{v^2}{r^2} + \frac{1}{2}.Mv^2 = 0.21Mg$ $(\frac{1}{2}) \quad (\frac{1}{2})$ $v^2 = 0.3g = 2.94$ Hence $\underline{v = 1.7 \text{ ms}^{-1}}$ (1)	$\omega = v/r$ for $(\frac{1}{2})$	4	
(ii)	For motion about O, Central force $= \frac{mv^2}{r} = M\frac{0.3g}{0.51}$ $(\frac{1}{2})$ Component of weight to centre $= Mg \sin\theta = Mg \frac{0.3}{0.51}$ $(\frac{1}{2})$ Since these are equal, R = 0 and sphere loses contact (1)	or similar comment	2	
(iii)	Loses contact when R = 0 i.e. $\frac{mv^2}{r} = mg \sin\theta$ $(\frac{1}{2})$ $\frac{1}{2}mv^2$ term is greater $(\frac{1}{2})$ since no $\frac{1}{2}I\omega^2$ term $(\frac{1}{2})$ Hence $\sin\theta$ and θ are greater and loses contact higher up. $(\frac{1}{2})$	some reason	2	8

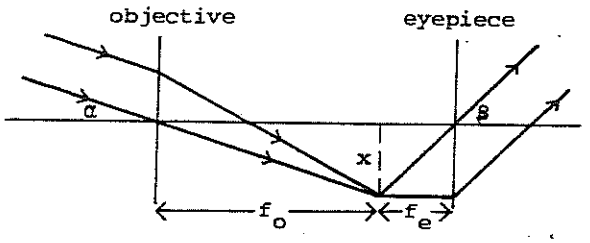
	Sample answer and mark allocation	Notes	Marks	
10 (a)	$F = \frac{Q_1Q_2}{4\pi\varepsilon_o r^2}$ (1) explanation of symbols (½) $E = \frac{dF}{dQ} = \frac{Q}{4\pi\varepsilon_o r^2}$ (½) + (½) $V = -\int_{(½)} E dr = -\int \frac{Q}{4\pi\varepsilon_o r^2} dr$ (½) $= -\frac{Q}{4\pi\varepsilon_o}\int \frac{dr}{r^2} = -\frac{Q}{4\pi\varepsilon_o}\left(\frac{-1}{r}\right)$ (½) $= \frac{Q}{4\pi\varepsilon_o r}$	or statement for 1½	4	4
(b) (i)	$V = \frac{30 \times 10^{-9}}{4\pi \times 8.85 \times 10^{-12} \times 20 \times 10^{-3}}$ (½) (½) $= \underline{13.5\ kV}$ (1)		2	
(ii)	 (½) (½) (1)	both axes both values shape	2	
(iii)	V inside 50 mm sphere $= \frac{-30 \times 10^{-9}}{4\pi \times 8.85 \times 10^{-12} \times 50 \times 10^{-3}}$ (½) (½) $= -5.4$ kV New potential at inner sphere $= 13.5 - 5.4 = \underline{8.1\ kV}$ (1)		2	
(iv)	 (½) (½)	new values new shape	1	7
(c) (i)	$(1 - \frac{v^2}{c^2})^{½} = \frac{1}{4}$ (½) $v^2 = \frac{15}{16} c^2$ (½) Hence $\underline{v = 2.9 \times 10^8\ ms^{-1}}$ (1)		2	
(ii)	$qV = (m - m_o)c^2$ $V = \frac{3m_oc^2}{q}$ (½) $= \frac{3 \times 9.11 \times 10^{-31} \times (3 \times 10^8)^2}{1.6 \times 10^{-19}}$ (½) $V = \underline{1.54 \times 10^6\ V}$ (1)		2	4

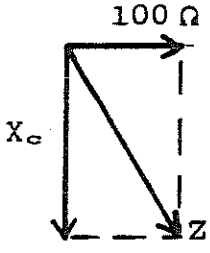
	Sample answer and mark allocation	Notes	Marks	
11 (a) (i)	$F = nBlI$ (½) $= 150 \times 2.4 \times 20 \times 2 \times 10^{-6}$ (½) $= \underline{1.44 \times 10^{-4}\ N}$ (1)		2	
(ii)	Perpendicular distance between sides = 20 cos 20 (mm) (½) Torque $= 1.44 \times 10^{-4} \times 20 \times 10^{-3} \cos 20$ (½) $= \underline{2.71 \times 10^{-6}\ Nm}$ (1)		2	
(iii)	Restoring torque per degree $= \underline{1.35 \times 10^{-7}\ Nm}$ (1)	accept Nm/degree	1	
(iv)	Restoring torque at 40° $= 40 \times 1.35 \times 10^{-7}$ (½) $= 1.44 \times 10^{-3} I \cos 40$ (½) Hence $I = \underline{4.9 \times 10^{-3}\ A}$ (1) OR $\frac{I_1 \cos 20}{20} = \frac{I_2 \cos 40}{40}$ (1) $I_2 = \frac{40}{20}.\frac{\cos 20}{\cos 40}.I_1$ $= \underline{4.9\ mA}$ (1)		2	
(v)	Field is <u>radial</u> due to <u>iron core</u> and <u>curved poles</u> on magnets (1)	(½) + (½) any two from three	1	8

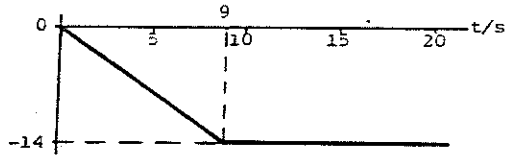
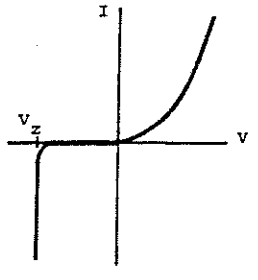
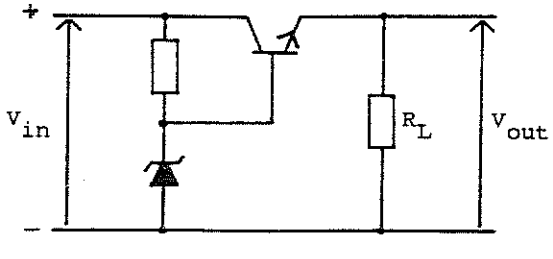
	Sample answer and mark allocation	Notes	Marks	
11 (b)	Magnetic induction distance r from wire proportional to I/r (1) Currents in <u>same direction</u> can make B equal and opposite <u>between</u> the wires (1) Reference to ratio of distances 5:1 same as ratio of currents (½) Currents in <u>opposite directions</u> can make B equal and opposite <u>beyond wires on right side</u> (1) Reference to ratio of distances 5:1 as before (½)	Equal and opposite fields may be shown in diagrams	4	4
(c)	Induced e.m.f. $= -L\frac{dI}{dt}$ (½) For sweep, $E = -4.5 \times 10^{-3} \times \frac{0.8}{63 \times 10^{-6}}$ (½) $= \underline{-57\ V}$ (1) For flyback, $E = -4.5 \times 10^{-3} \times \frac{-0.8}{10^{-6}}$ $= \underline{3.6\ kV}$ (1)	signs of voltages must be opposite	2 1	3

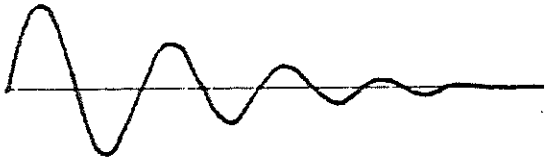
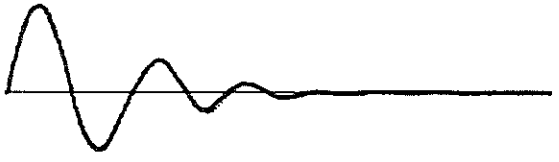
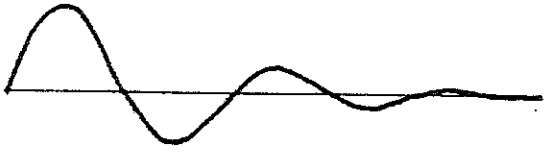
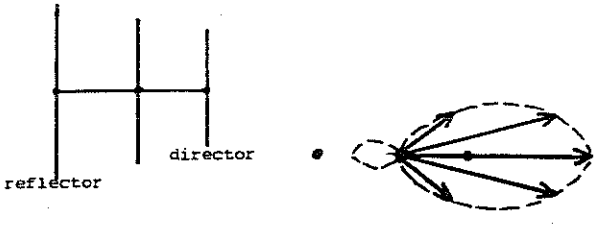
	Sample answer and mark allocation	Notes	Marks	
12 (a) (i)	$x = 4\cos(\frac{\pi}{5}t + \frac{\pi}{2})$ $v = \frac{dx}{dt} = -4\frac{\pi}{5}\sin(\frac{\pi}{5}t + \frac{\pi}{2})$ (1)		1	
(ii)	Displacement after 12.5 s $x = 4\cos(2.5\pi + \frac{\pi}{2})$ (½) $= 4\cos 3\pi = \underline{-4\ m}$ (1½) Distance = 4m per π/2 of time = 20 m (1)		3	
(iii)	Speed max when $\sin(\frac{\pi}{5}t + \frac{\pi}{2}) = 1$ (½) i.e. when $\frac{\pi}{5}t + \frac{\pi}{2} = \frac{\pi}{2}$ or $\frac{3\pi}{2}$ (½) i.e. when $\underline{t = 0}$ (½) or $\underline{t = 5\ s}$ (½) Speed = $\frac{4\pi}{2}\sin\frac{\pi}{2} = \underline{2.5\ ms^{-1}}$ (1)		3	7
(b) (i)	Downward acceleration of platform is equal to g (1)	greater than g (½) just greater than g (1)	1	
(ii)	$a = -\omega^2 x$ (½) $9.8 = \omega^2 \times 0.1$ (1) $4\pi^2 f^2 = 9.8/0.1$ (½) frequency f = 1.6 Hz (1)	-ve sign -(½)	3	4
(c) (i)	De Broglie wavelength $\lambda = h/mv$ (½) for neutron at velocity v = c/200 $\lambda = \frac{6.63 \times 10^{-34}}{1.675 \times 10^{-27} \times 1.5 \times 10^{6}}$ (½) $\lambda = \underline{2.64 \times 10^{-13}\ m}$ (1)		2	
(ii)	$2\pi r = n\lambda$ (½) De Broglie $\lambda = h/mv$ $2\pi r = nh/mv$ (½) Ang mom $mvr = nh/2\pi$ (½) Comment (½)		2	4

	Sample answer and mark allocation		Notes	Marks	
13 (a)		(1)	Label O, I & F (½) two rays for image (½)		
	$\frac{1}{u} + \frac{1}{v} = \frac{1}{f}$	(½)			
	$\frac{1}{45} + \frac{1}{v} = \frac{1}{50}$ (v = −450)	(½)			
	image is 45 cm from lens	(1)			
	virtual, magnification x10	(1)		4	4
(b) (i)	Depth of focus is range of film distance where image is in reasonable focus	(½)	may be in diagram		
	Depth of field is range of object distance giving same	(½)		1	
(ii)		(2)	or description	2	3
(c)	Effective diameter of 28 mm lens at f/4 = 7 mm	(½)			
	Effective diameter of 80 mm lens at f/4 = 20 mm	(½)			
	Distance from lens to film approximately the same	(½)			
	Choice of 80 mm for close-up	(½)			
	Link larger diameter to smaller depth of focus/field	(1)		3	3
(d) (i)	1 reverses image laterally	(½)	or horizontally		
	2 inverts image	(½)	or reverses vertically	1	
(ii)					
	In diagram:				
	distinction between rays	(½)	or statement		
	arrows on rays	(½)			
	two rays drawn showing t.i.r.	(1)	(½) + (½)	2	3

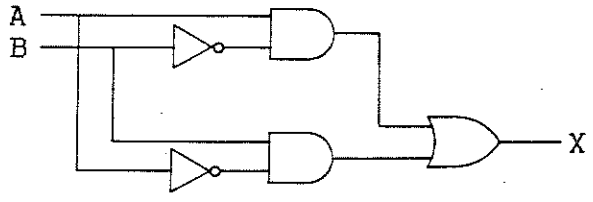
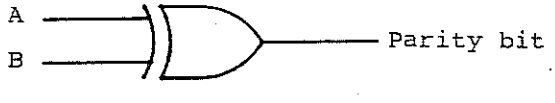
	Sample answer and mark allocation	Notes	Marks
13 (e) (i)	 (1)	Lenses separated by sum of focal lengths	1
(ii)	Angular magnification $= \beta/\alpha = \tan\beta/\tan\alpha$ (½) (½) $= \frac{x/f_e}{x/f_o} = \frac{f_o}{f_e}$ (½) Ang mag = 500/20 = <u>25</u> (½)	must have both for (1)	2
(iii)	Object is at $(f_o + f_e)$ (½) $\frac{1}{f_o + f_e} + \frac{1}{v} = \frac{1}{f_e}$ (½) $\frac{1}{v} = \frac{1}{f_e} - \frac{1}{f_o + f_e}$ (½) $\frac{1}{v} = \frac{f_o}{f_e(f_o + f_e)}$ (½)		2
(iv)	Magnification of eyepiece is $v/u = f_e/f_o$ Diameter of exit pupil $= \frac{20}{500} \times 60 = \underline{2.4\text{ mm}}$ (1)		1
(v) (A)	Image would not fill field of view of eye (½)	or equivalent	
(B)	Not all light forming image would enter the eye (½)		1 7

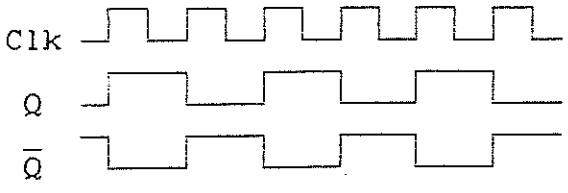
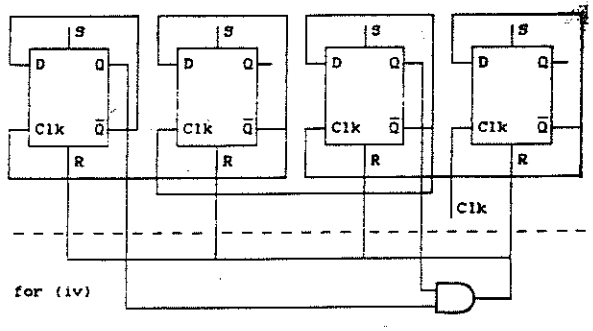
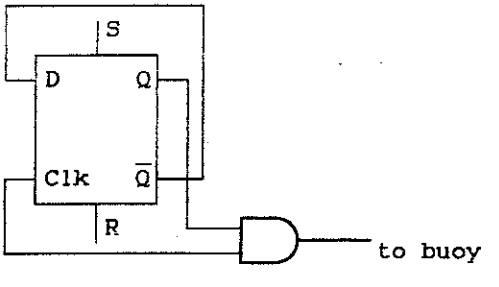
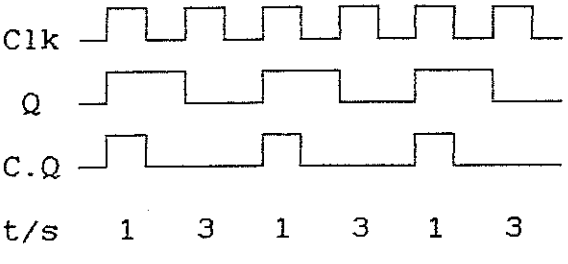
	Sample answer and mark allocation	Notes	Marks	
14 (a) (i)	$V = V_o \sin 2\pi ft$ $Q = CV = CV_o \sin 2\pi ft$ (½) $I = \frac{dQ}{dt} = 2\pi fCV_o \cos 2\pi ft$ (½) $I_o = 2\pi fCV_o$ (½) $X_c = \frac{V_o}{I_o} = \frac{1}{2\pi fC}$ (½)		2	
(ii)	 $Z = \sqrt{100^2 + X_c^2}$ $= 200$ (½) $X_c^2 = 200^2 - 100^2$ $X_c = 100\sqrt{3}$ (½) $X_c = \frac{1}{2\pi fC} = 100\sqrt{3}$ $f = \frac{1}{2\pi\ C.100\sqrt{3}} = 9.19$ Hz (1)		2	4
(b)	Positive feedback increases amplitude of input (½) and increases gain (½) Negative feedback decreases amplitude of input (½) and decreases gain (½) Advantages:- increases stability reduces distortion (1) increases bandwidth	any two for (½) each	3	3
(c) (i)	Let feedback current be I then $I = C\frac{d(V_{out} - 0)}{dt}$ $I = C\frac{d(V_{out})}{dt}$ (½) inverting input is virtual earth $0 - V_{in} = IR$ $I = \frac{-V_{in}}{R}$ (½) Equating expressions for I $\frac{-V_{in}}{R} = C\frac{d(V_{out})}{dt}$ (½) $V_{out} = \frac{-1}{RC}\int V_{in}\, dt$ (½)		2	

	Sample answer and mark allocation	Notes	Marks	
14 (c) (ii)	$V_{out} = -\frac{1}{RC}\int V_{in}\,dt$ When t = 5s $V_{out} = -\frac{1}{10^6 \times 2 \times 10^{-6}} \times 3 \times 5$ $= -15/2 = \underline{-7.5\ V}$ (1)		1	
(iii)	V_{out}  (½) label axes (½) V_{out} -ve < 15 V (½) at time < 10 s (½) graph line		2	5
(d) (i)	 axes (incl V_z) (½) line (½)		1	
(ii)	As supply voltage is increased at V_z <u>reverse resistance falls</u> and current is limited by R_s <u>Increase in V_s beyond V_z</u> increases <u>voltage drop across R_s</u> so <u>V_z remains constant</u> (2)	4 x (½)	2	
(iii)	Voltage across R_s = 3.8 V (½) Max current in zener (½) $= \frac{3.8}{150} = \underline{0.025\ A}$ (1)		2	
(iv)	Theoretically all current in R_L $R_L = \frac{6.2}{0.025} = \underline{248\ \Omega}$ (1)	or $\frac{6.2}{0.0253} = \underline{245\ \Omega}$	1	
(v)	 (2)	no supply –(½) no V_{out} –(½) wrong polarity 0 marks	2	8

	Sample answer and mark allocation	Notes	Marks	
15 (a) (i)	 (1)		1	
(ii)	 (1)	same f fewer waves to zero	1	
(iii)	 (1)	lower f fewer waves than (i)	1	
(iv)	By supplying energy <u>in phase</u> (½) at <u>correct frequency</u> (½)	or <u>same</u> frequency	1	4
(b)	$f_o = \frac{1}{2\pi\sqrt{LC}}$ (½) $= \frac{1}{2\pi(2.5 \times 10^{-3} \times 100 \times 10^{-12})^{\frac{1}{2}}}$ (½) f_o = <u>318 kHz</u> (1)	use of min. L & C	2	2
(c) (i)	Wave with <u>electric field vector</u> (½) existing in <u>only one plane</u> (½)		1	
(ii)	 (2) (1)	each position and size 4 x (½) not distinguished -(½)	3	
(iii)	Signals would be <u>out of phase</u> (½) and cause <u>interference</u> (½) If polarized differently, <u>receiving aerial</u> will pick up (½) <u>only the one</u> signal. (½)		2	6

	Sample answer and mark allocation		Notes	Marks	
15 (d) (i)	Upper sideband				
	810.05 to 818 kHz	(1)	(½) + (½)		
	Lower sideband				
	809.95 to 802 kHz	(1)	(½) + (½)	2	
(ii)	794 kHz or 826 kHz	(1)		1	3
(e)	A - local oscillator B - mixer C - i.f. amplifier D - detector or decoder E - a.f. amplifier	(2)	-(½) for each error	2	
	Functions of <u>any two</u> of above				
	A - <u>produces</u> a signal <u>465 kHz above signal</u> frequency		2 x (1½) quality of answer		
	B - <u>mixes these two</u> to produce a <u>465 kHz signal</u> now carrying the <u>modulation</u>				
	C - <u>amplifies</u> the <u>modulated 465 kHz</u> signal				
	D - <u>separates</u> <u>a.f.</u> signal from <u>i.f.</u> carrier				
	E - <u>amplifies</u> the <u>a.f.</u> signal			3	5

	Sample answer and mark allocation		Notes	Marks	
16 (a) (i)		(2)	A,B to each AND (½) OR gate in and out (1)	2	
(ii)	A B $\bar{A}$ $\bar{B}$ A.$\bar{B}$ $\bar{A}$.B X 0 0 1 1 0 0 0 0 1 1 0 0 1 1 1 0 0 1 1 0 1 1 1 0 0 0 0 0	(2)	(½) each line	2	
(iii)	Exclusive OR	(1)	XOR, E-OR, EX-OR	1	5
(b) (i)	Closing Q_1 all inputs low - output 00	(½)			
	Closing Q_2 one input to G_1 high - output 01	(½)			
	Closing Q_3 one input to G_2 high - output 10	(½)			
	Closing Q_4 one input to G_1 and G_2 high - output 11	(½)		2	
(ii)	Even parity means that the total number of '1's in the data string together with the parity bit is even.	(1)		1	
(iii)		(1)		1	4

	Sample answer and mark allocation	Notes	Marks	
16 (c) (i)	 (1) (1)		2	
(ii)	Division by 2 (1)		1	
(iii)	 (2)		2	
(iv)	Reset after 9 by ANDing Q outputs from 8 and 2 and applying this to all reset R inputs. (1) Added to diagram for (iii) (1)		2	7
(d) (i)	 (2)	would it work? all or nothing	2	
(ii)	 ($\frac{1}{2}$) ($\frac{1}{2}$) (1)	must be clearly labelled	2	4

END OF MARKING INSTRUCTIONS