WJEC EDUQAS A-LEVEL PHYSICS · COMPONENT 3

PHYSICS



EXAM QUESTION PACK

OPTION A: ALTERNATING CURRENTS

SCORE	PERCENTAGE
/80	%

STEMUP

These questions belong to WJEC Eduqas, not to us.

The examination questions, mark schemes and examiner comments in this pack were written and published by WJEC Eduqas. They are past assessment materials, reproduced here so that students can revise from them.

What we do not own

STEMUP is not affiliated with WJEC Eduqas and does not own, and makes no claim to own, any of the question, mark scheme or examiner report material in this pack. WJEC Eduqas has not endorsed, approved or been involved in the production of it. WJEC Eduqas and the qualification titles used here belong to their respective owners and appear for identification only.

Where to find the originals

WJEC Eduqas publishes its past papers, mark schemes and examiner reports free of charge. Always check the current specification at eduqas.co.uk before you revise, because content and wording can change between series.

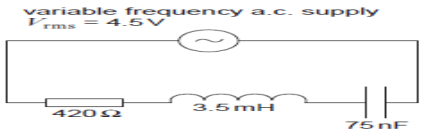
If you hold the rights to any material in this pack and would like it amended or removed, contact admin@stemup.co.uk and we will act on it.

#1

(a) With the aid of a phasor diagram, explain why the impedance of an RCL circuit is given by: [3]

$$Z = \sqrt{(X_L - X_C)^2 + R^2}$$

(b) Consider the following RCL circuit.

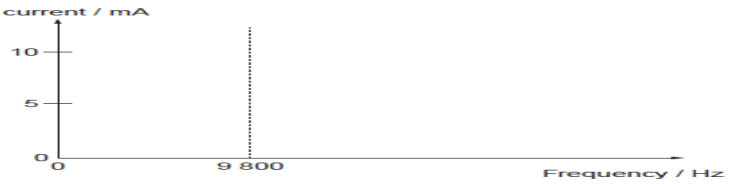


(i) Show that the combined magnitude of the reactance of the inductor and capacitor is the same (to 3 s.f.) as the resistance of the resistor when the frequency is 4 150 Hz. [3]

(ii) Hence, calculate the rms current in the circuit when the frequency is 4 150 Hz. [3]

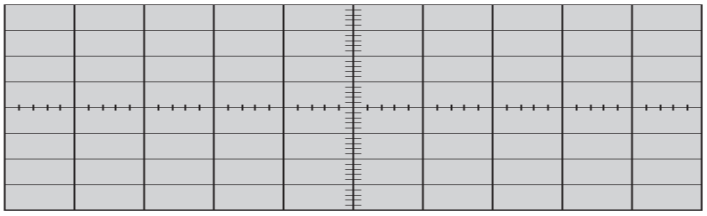
(iii) Calculate (or state) the phase angle between the applied pd and the current when the frequency is 4 150 Hz. [1]

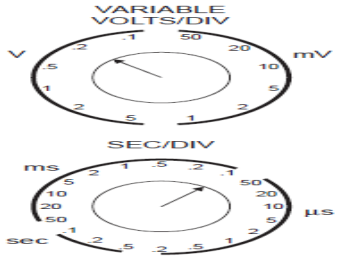
(iv) The resonance frequency of the RCL circuit is approximately 9 800 Hz. **By sketching** a graph of rms current against frequency, explain why there is a second higher frequency that provides the same rms current as your answer to *(b)*(ii). [3]



(v) This second frequency occurs when the magnitude of the reactances of the inductor and capacitor are reversed from those in part *(b)*(i). Use this information to calculate this second frequency. [2]

(c) Robyn is required to produce a wave trace on an oscilloscope for an a.c. power supply of frequency 3.0 kHz and rms pd 0.60 V. Deduce whether or not the settings of the oscilloscope shown below are appropriate. [5]

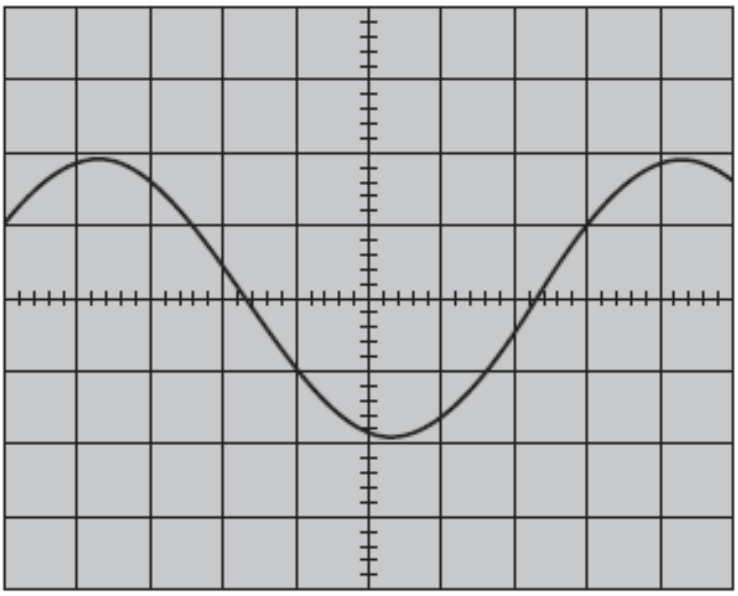


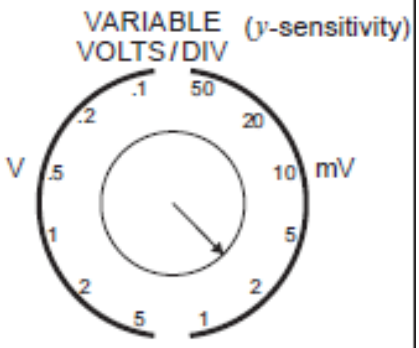


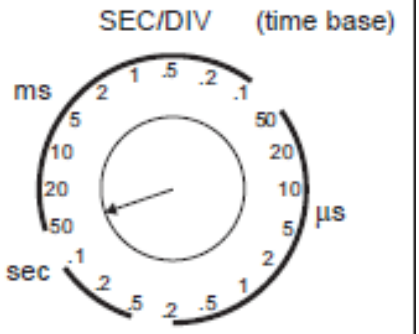
Question taken from Eduqas examination paper 842103, November 2020

#2

11. An oscilloscope trace is shown along with the settings of the y-sensitivity and the time base.







(a) (i) Calculate the **rms** pd of the oscilloscope trace shown. [2]

.....

.....

.....

.....

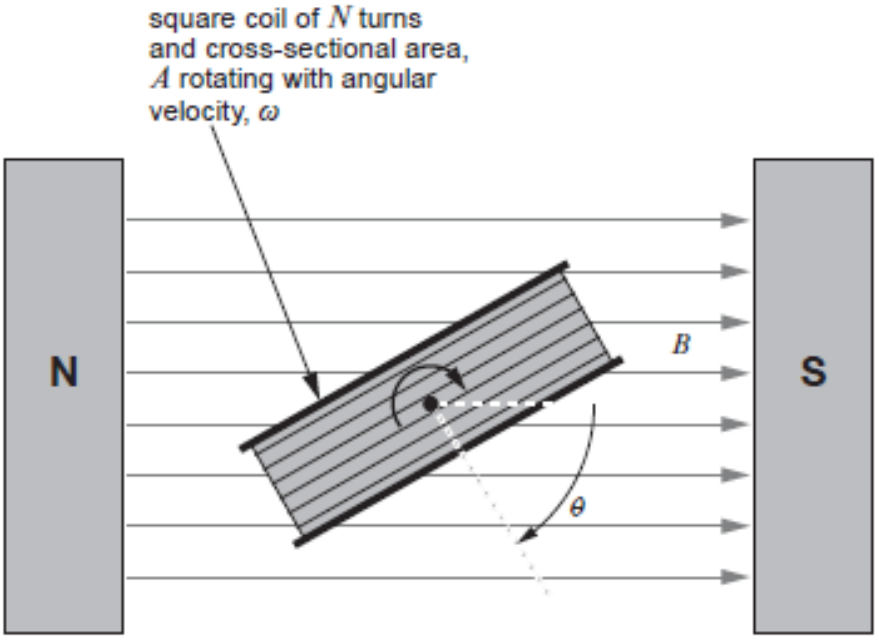
(ii) Calculate the frequency of the oscilloscope trace shown. [2]

.....

.....

.....

(b) A coil rotates in a magnetic field as shown.



(i) Use Faraday's Law to explain why the peak emf induced in the coil is proportional to the angular velocity of rotation of the coil. [2]

.....

.....

.....

.....

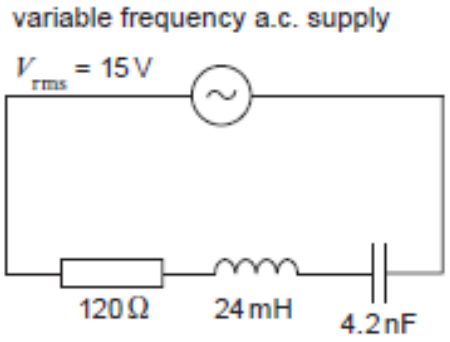
(ii) Use Faraday's Law to explain why the emf induced in the coil depends on the angle, θ. [2]

.....

.....

.....

(c) (i) In the following LCR circuit, explain why the rms resonance current is 125 mA. [2]



.....

.....

.....

.....

(ii) Calculate the resonance frequency of the circuit. [2]

.....

.....

.....

.....

(iii) Show that the rms current is 42 mA when the frequency of the supply is 17 kHz. [3]

.....

.....

.....

.....

.....

.....

.....

.....

STEMUP.CO.UK

(iv) Alistair claims that the mean power dissipation in the circuit at 17 kHz is:

$$P = I_{rms} V_{rms} = 0.042 \times 15 = 0.63\,W$$

Another student Michonne states that the correct value of power is 0.21 W.
Deduce which, if either, of the students is correct. [5]

Question taken from Eduqas examination paper 842103, June 2018

#3

11. *(a)* Derive the expression for the resonance frequency, f_0, of a series RCL circuit. [3]

$$f_0 = \frac{1}{2\pi\sqrt{LC}}$$

.....

.....

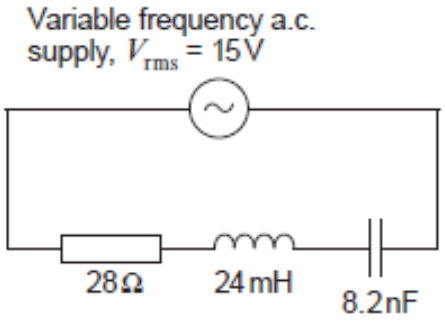
.....

.....

.....

.....

(b) Consider the following RCL circuit.



(i) Calculate the rms current at the resonance frequency (f_0). [1]

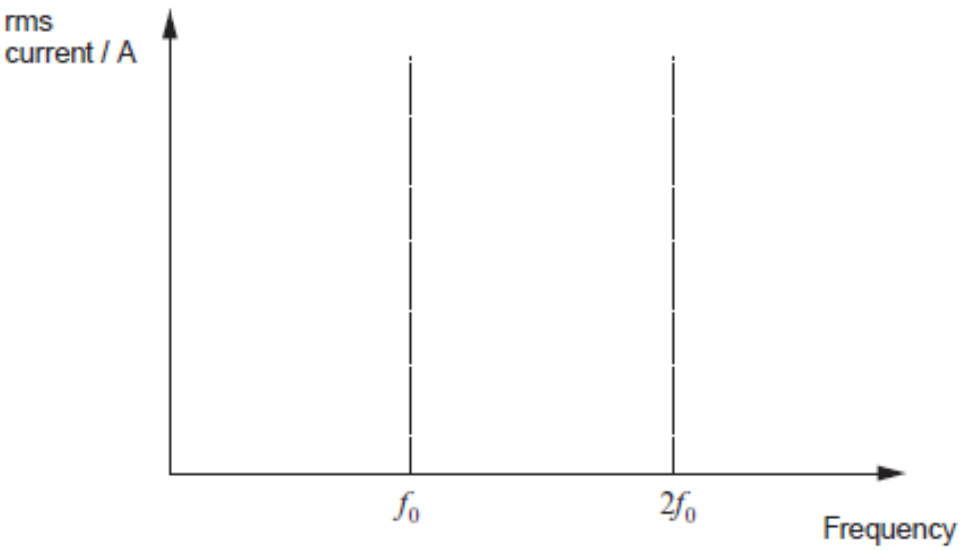
.....

.....

(ii) Calculate the rms current at twice the resonance frequency ($2f_0$). [4]

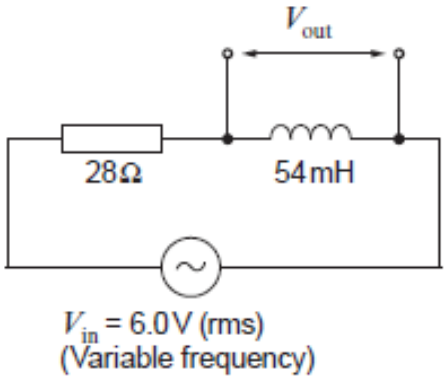
(iii) Calculate the Q factor of the RCL circuit. [2]

(iv) Sketch a graph of the rms current in the RCL circuit versus applied frequency of the a.c. supply on the axes provided. Label this graph 28 Ω. [3]



(v) The 28 Ω resistor is replaced by a 56 Ω resistor. On the same axes, sketch and label a second graph showing the rms current versus frequency for the new circuit. [2]

(c) Morgan claims that the rms output pd (V_{out}) in the following circuit is greater than 4.25 V when the frequency is greater than 82.5 Hz but less than 4.25 V below 82.5 Hz. Investigate whether or not Morgan is correct. [5]



Question taken from Eduqas examination paper 842103, June 2019

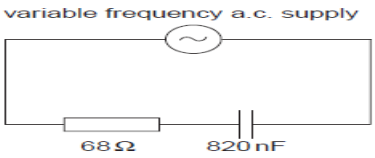
#4

(a) A 900 W toaster is supplied with a sinusoidally varying pd of **peak** pd 325 V. Calculate:

(i) the **rms** current; [2]

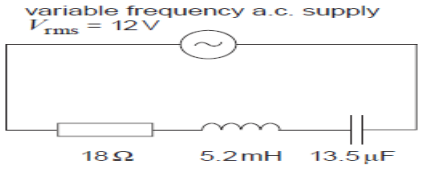
(ii) the resistance of the toaster. [2]

(b) Helen claims that the following circuit will have a minimum impedance of 68 Ω when the frequency is very low but that the impedance will be extremely large at high frequencies.



Deduce whether or not Helen is correct. [5]

(c) (i) Explain why the rms current at resonance of the following circuit is approximately 700 mA. [2]



(ii) Show that the resonance frequency (f_0) is approximately 600 Hz. [2]

(iii) Calculate the rms current when the frequency of the supply is increased to $1.5f_0$. [4]

(iv) Explain why the rms current is the same when the frequency is decreased to $\frac{f_0}{1.5}$. [3]

Question taken from Eduqas examination paper 842103, June 2017

Marking Scheme

#1

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
	(a)		Correct phasor diagram, labelled Explanation of subtracting reactances Pythagoras or similar for final step 	3			3		
	(b)	(i)	Substitution into $X_L=\omega L$ (1) Substitution into $X_C=(\omega C)^{-1}$ (1) 511-91 = 420 [Ω] (1)	1 1	 1		3	1	
		(ii)	$420\sqrt{2}$ or similar seen for impedance e.g. $\sqrt{R+R}$ (1) Use of $I=\frac{V}{Z}$ (1) Answer = 7.58 m[A] (1)		3		3	3	
		(iii)	45°		1		1	1	
		(iv)	Shape correct (1) Max current = 10.7 m[A] (approx., by eye) (1) Explanation or horizontal line right from 4 150 Hz point (1)	1	 1 1		3	1	
		(v)	Either X_L = 511 or X_C = 91 used **OR** quadratic equation set up (1) Answer = 23 250 [Hz] (1)		2		2	1	
	(c)		Period = 0.333 m[s](1) So 1 cycle is 3.33 [cm] (1) Peak pd is 0.85 [V] (1) i.e. 4 and a bit squares (1) Conclusion: Time scale OK, volts/div not quite (1)			5	5	3	
			Question total	**6**	**9**	**5**	**20**	**10**	**0**

#2

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
11	*(a)*	(i)	1.8 - 1.9 squares for peak (or 3.6 - 3.8 for double) Or 0.002× and $I/\sqrt{2}$ (1) Answer = 2.5 – 2.7 mV (1)		2		2	2	
		(ii)	7.9 - 8.3 squares for period Or 0.05 × and $f = \frac{1}{T}$ (1) Answer = 2.4 – 2.5 Hz (1)		2		2	2	
	(b)	(i)	Pd proportional to rate of change/cutting of flux (linkage) (1) Rate of change/cutting is proportional (accept increases with) angular velocity (1)	2			2		
		(ii)	Vertical: no flux cut/flux does not change (1) Horizontal: flux cut/changes at max rate (1) **Alternative:** rate of change/cutting depends on angle (1) Clarification e.g. vertical component of velocity does cutting Or vertical/horizontal positions explained briefly (1)	2			2		
	(c)	(i)	Pds across C and L cancel or equivalent (1) $I = \frac{15}{120}$ (1)	1	1		2	1	
		(ii)	Valid method employed e.g. $X_C = X_L$ (1) Answer = 15 850 Hz (1)		2		2	1	
		(iii)	X_C and X_L calculated correctly (or implied, 2 229, 2 564) (1) Impedance equation used (1) $I = \frac{15}{355}$ seen or 42.3 mA (1)	1	1 1		3	2	
		(iv)	RMS values used – correct (1) Current not in phase with pd or all pd not across R (1) Actual power is $I_{rms}{}^2R$ or equivalent (1) Real value is 0.21 W (1) Conclusion – invalid calculation (1) Or Current not in phase with pd so cannot use $\langle P \rangle = V_{rms}I_{rms}$ (1) So Alistair is incorrect (1) Only resistor dissipates power so $\langle P \rangle = I_{rms}^2 R$ is valid (1) So real value is 0.21 W (1) So Michonne is correct (1)			5	5	2	
			Question 11 total	**6**	**9**	**5**	**20**	**10**	**0**

#3

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
11	(a)		$X_L = X_C$ or impedance cancel or $V_L = V_C$ [1] $\omega L = \frac{1}{\omega C}$ [1] $\omega = 2\pi f$ and reasonable algebra [1]	3			3	1	
	(b)	(i)	$I = \frac{V}{R} = \frac{15}{28} = 0.536$ [A]		1		1	1	
		(ii)	Resonance frequency = 11.35 k[Hz] calculated or implied [1] X_L or X_C calculated e.g. 3440 [Ω] or 851 [Ω] [1] Total impedance calculated or implied [Z = 2589 Ω] [1] $I = \frac{V}{Z}$ giving answer = 5.8 m[A] [1]		4		4	4	
		(iii)	$Q = \frac{\omega L}{R}$ or similar used [1] Answer = 61.4 [1]	1	1		2	1	
		(iv)	Shape correct [1] Asymptotes correct [1] I at $2f$ much smaller than I at f [1]	1 1	1		3		
		(v)	Same shape & resonant frequency [1] Peak is half height (by eye or labelled) [1]		2		2		
	(c)		Statement that X_L increases with frequency or vice versa [1] ωL obtained at 82.5 Hz giving 27.99 Ω or 28 Ω [1] Z obtained as 39.6 Ω or realising $\frac{V_0}{\sqrt{2}}$ or equivalent [1] V_{out} confirmed as 4.25 V [1] Correct conclusion stated [1]			5	5	3	
			Question 11 total	**6**	**9**	**5**	**20**	**10**	**0**

#4

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
	(a)	(i)	Converting peak to rms (1) Answer = 3.9 [A] (1)	1	1		2	1	
		(ii)	Use of $P = I^2 R$ (1) Answer = 64 [Ω] (1)	1	1		2	1	
	(b)		Use of $X_C = \frac{1}{\omega C}$ to explain frequency variation (1) Realisation that X_C is large at low freq or low at high freq (1) Hence 68 Ω at high freq (1) Infinite/high at zero freq/low freq (1) Helen is wrong on both counts (1)			5	5	2	
	(c)	(i)	All pd across R at resonance or reactances of capacitor and inductor cancel (accept $Z = R$ at resonance) (1) $I = \frac{12}{18}$ or 667 m[A] or 0.67[A] etc. (1)	2			2	1	
		(ii)	Use of valid equation e.g. $\omega^2 = \frac{1}{LC}$ (1) $f = \sqrt{\frac{1}{4\pi^2 \times 0.0052 \times 13.5 \times 10^{-6}}}$ or 600.7 [Hz] (1)	1	1		2	1	
		(iii)	X_L or X_C calculated correctly (29.4 or 13.1) (1) Calculation of $Z = \sqrt{(X_L - X_C)^2 + R^2}$ (= 24.3 Ω) (1) Use of $I = \frac{V}{Z}$ (1) Answer = 0.494 [A] (1)	1	1 1 1		4	1	
		(iv)	X_L decreases by 1.5 or X_C increases by 1.5 (accept 2.25) (1) X_L and X_C swap values from part (iii) (1) $\sqrt{(X_L - X_C)^2 + R^2}$ or $(X_L - X_C)^2$ is unaffected (1)		3		3	3	
			Question total	**6**	**9**	**5**	**20**	**10**	**0**