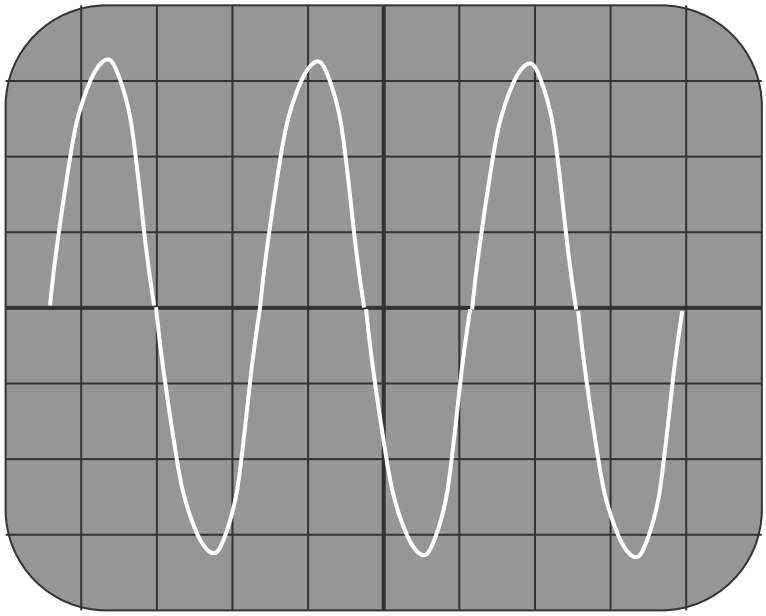
Leeds City College

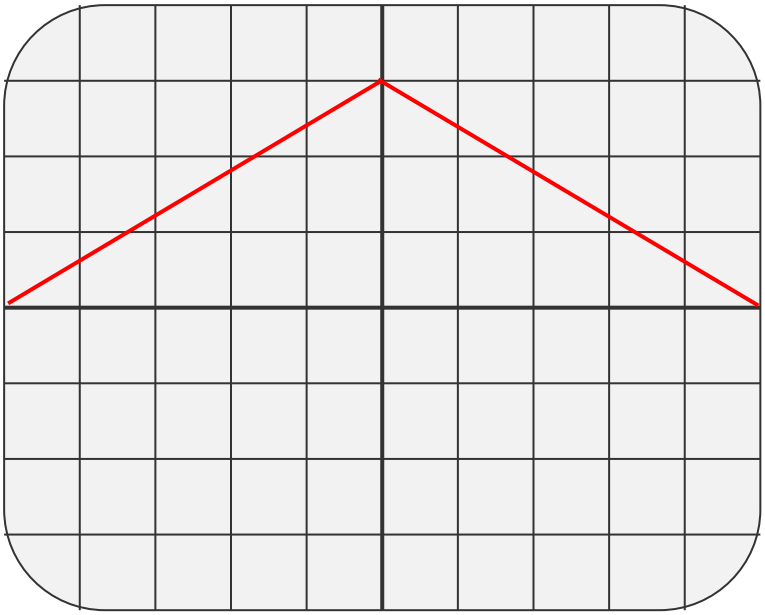
Name:

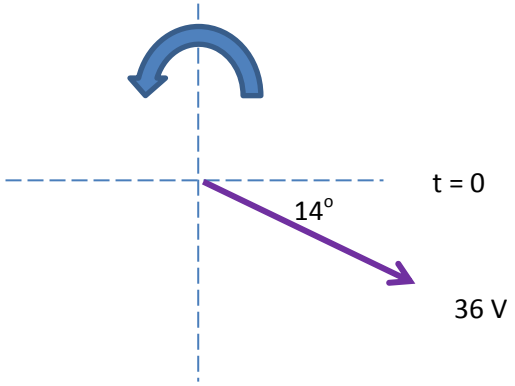
Test on Electrical Principles (Answers)

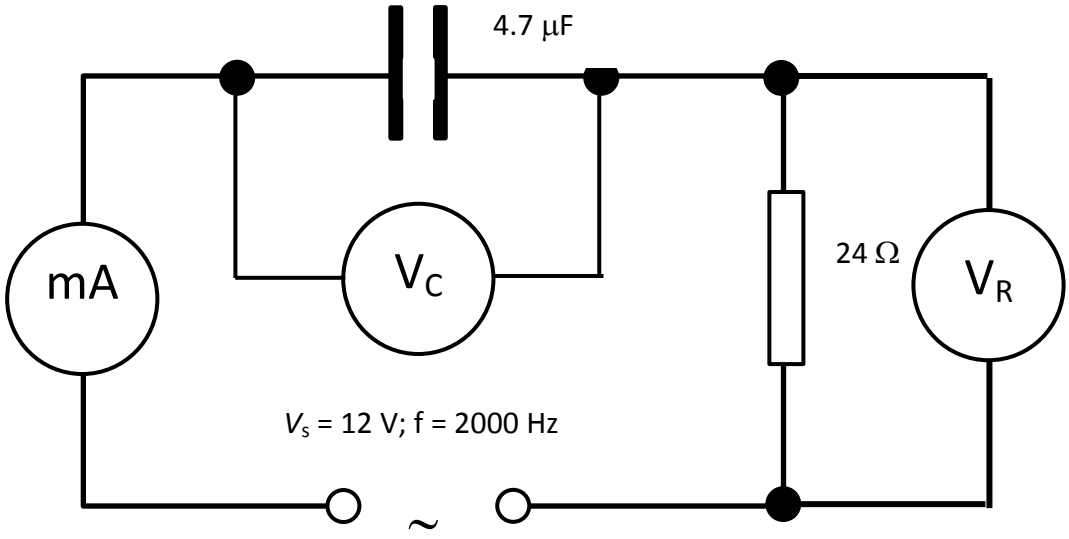
Examination Time – 75 minutes

- *Credit should be awarded for correct answers outside this marking scheme;*
- *Alternative valid methods of working out will be awarded full credit;*
- *Errors can be carried forward for full credit.*

1.	The CRO screen shows an alternating sinusoidal wave-form.  The time base is set to 2 ms/cm; The voltage gain is set to 1 V/cm. Each square is 1 cm.		
	(a)	Show that the peak-to-peak voltage is about 6.5 V	(1)
	6.5 squares		✓
	1 cm = 1 V ⇒ 6.5 V		✓
	(b)	What is the peak voltage?	(2)
	6.5 ÷ 2		✓
	V_0 = 3.25 V		✓

	(c)	What is the RMS voltage?	(2)
	$V_{RMS} = 3.25 \div \sqrt{2}$		✓
	V_{RMS} = 2.30 V		✓
	(d)	Calculate the frequency of this wave	(3)
	T for 3 waves = 8.4 cm × 2 ms = 16.8 ms		✓
	T = 16.8 ÷ 3 = 5.6 ms		
	$f = 1 \div 5.6 \times 10^{-3}$		✓
	Frequency = 180 Hz		✓
	(e)	Explain the difference between an alternating and a unidirectional waveform.	(2)
	AC wave form goes between 0 and $+V_0$ and 0 and $-V_0$		✓
	Unidirectional wave form just goes from 0 to $+V_0$		✓
	(f)	On the blank CRO screen draw one cycle of a symmetrical **unidirectional** triangular wave of peak voltage 1.5 V and frequency 100 Hz. Assume that the centre line is at zero volts  State what the voltage gain control and the time-base control are set at.	(4) ✓ ✓
	Time-base: 1×10^{-3} s/cm		✓
	Voltage-gain: 0.5 V/cm		✓
			14

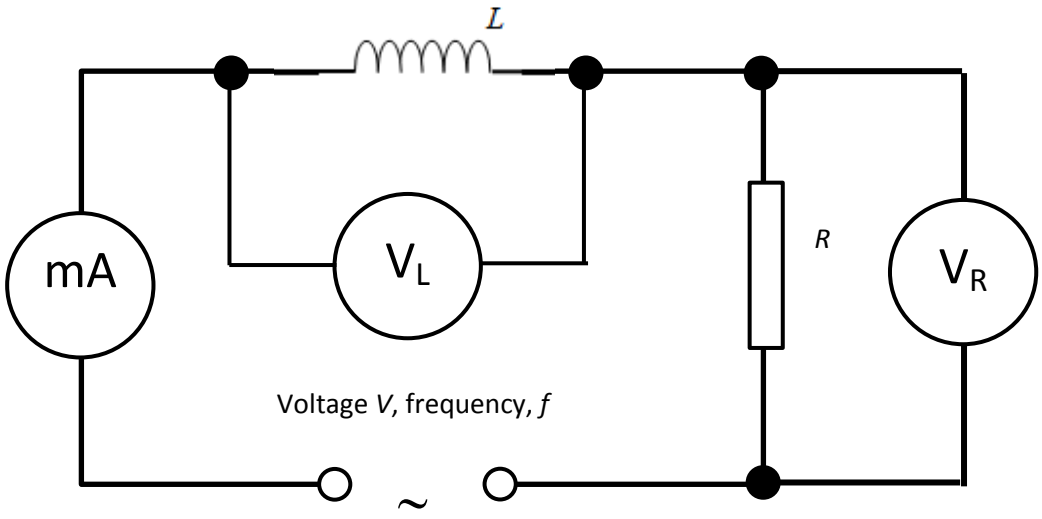
2.	An alternating voltage is given by the expression: $V = 36\sin[(30\pi t) - 0.25]$		
	(a)	What is the amplitude?	(1)
	Amplitude = 36 V		✓
	(b)	Show that the frequency of the wave is 15 Hz	(2)
	$\omega = 2\pi f \Rightarrow f = \omega/2\pi$		✓
	$f = 30\pi \div 2\pi$ (=15 Hz)		✓
	(c)	Draw a phasor diagram for this wave when t = 0. Show the direction of rotation and the phase angle in degrees.	(4)
			✓ ✓ ✓ ✓
	(d)	Show that the voltage when t = 100 ms is about 9 V	(3)
	V = 36 sin [(30 × p × 0.1) – 0.25]		✓
	V = 36 sin [3 p – 0.25] = 36 sin [9.425 – 0.25] = 36 sin [9.175]		✓
	V = 36 × 0.247 = 8.91 V (≈ 9 V)		✓
	(e)	The waveform is connected to a resistor of resistance 30 Ω. Calculate the maximum current and write a suitable equation for the current. Give a reason for your answer	(5)
	$I_0 = 36 \div 30$		✓
	Current = 1.2 A		✓
	Equation: I = 1.2 sin [(30πt) – 0.25]		✓✓
	Reason: Voltage and current are in phase for a resistor		✓
			15

3.	 The capacitor in this circuit has a capacitance of 4.7 μF. It is connected to a sinusoidally alternating supply of 12 V of frequency 2000 Hz. It is also connected to a resistor of resistance 24 Ω.		
	(a)	Show that the reactance of the capacitor is about 17 ohms.	(2)
	$X_C = 1/(2\pi \times 2000 \times 4.7 \times 10^{-6})$		✓
	$X_C = 16.9\ \Omega$		✓
	(b)	Calculate the impedance of the circuit. Give the unit.	(3)
	$Z^2 = 16.9^2 + 24^2 = 863$		✓
	$Z = \sqrt{863} = 29.4$		✓
	Impedance = 29 Ω		✓
	(c)	Calculate the current flowing in the circuit. Give your answer to an appropriate number of significant figures.	(3)
	$I = 12 \div 29.37$		✓
	$I = 0.409$ A		✓
	Current = 410 mA		✓
	(d)	Work out the phase angle between the source voltage and the voltage in the resistor.	(2)
	$\tan \phi = 16.9 \div 24 = 0.704$		✓
	$\phi = \tan^{-1} 0.704$		
	Phase angle = 35 degrees		✓
			10

4.	A motor connected to an AC supply can be modelled as an inductor in series with a resistor.		
	(a)	In a demonstration, a 240 V **universal** motor is connected to a low voltage DC power supply. It starts to turn when the voltage reaches about 8 V, and is turning rapidly by the time the voltage reaches 12 V. When it is connected to a 20 V AC supply, nothing happens. Explain these observations.	(3)
	The motor has an inductance…		✓
	…as it has coils of wire and magnetic components.		✓
	The reactance of the inductor is zero with DC…		✓
	…but quite high with AC. (*Any 3 points*)		✓
	Many machines use **induction** motors which can be modelled in exactly the same way. A customer wants to buy this circular saw from a leading supplier.  In looking at the information supplied with the saw, he sees that the power is as shown: Voltage = 230 V AC Power = 2200 W The supplier says that a 16 A supply is needed.		
	(b)	The customer knows a bit about basic electricity, but nothing about the electrical engineering you have done. He calculates (correctly using $P = VI$) the current and gets an answer of about 9.6 A. Explain to him why wiring the machine to an ordinary mains plug is not a good idea and that a 16 A supply is recommended. The quality of technical authorship will be assessed in this question.	(8)
	His calculation is the true power.		✓
	He has not taken into account the power factor.		✓
	The apparent power = true power ÷ power factor		✓
	The current = apparent power ÷ voltage.		✓
	So the current is rather higher than expected.		✓
	(*Any 4 for 1 mark each)*		

	QWC		
	4 – Outstanding quality of written English. Technical terms used correctly		
	Coherent piece of writing.		
	3 – Good quality of written English. Technical terms mostly used correctly		
	Good structure to the writing.		
	2 – Some errors in the written English. Some technical terms used.		
	Writing has structure, but can be unclear. Some irrelevant material.		
	1 – Poor standard of writing, with few technical terms used.		
	Writing is unclear, and there is quite a lot of irrelevant material.		
	0 – Standard of written communication is well below expected.		
	Answer is mostly or completely irrelevant. Points appear random.		
	OR question not attempted.		
	(c)	What is the true power of this machine? Give the unit.	(2)
	True power = 2200 W		✓
	(d)	The power factor in this machine is known to be 0.716. Calculate the apparent power of the machine and give the correct unit.	(3)
	$P = S \cos \phi$		
	$S = 2200 \div 0.716$		✓
	$S = 3070$		✓
	Apparent power = 3070 VA		✓
	(e)	Calculate the current.	(2)
	$I = 3073 \div 230$		✓
	Current = 13.4 A		✓
			15

5.



The frequency is set at 1500 Hz and the current is measured at 50 mA. The voltage across the resistor is found to be 10 V while the voltage across the inductor is found to be 6 V.

(a) Show that the supply voltage is just under 12 V (2)

$V^2 = 10^2 + 6^2 = 136$ ✓

$V = \sqrt{136} = 11.6$ V ($\approx$ 12 V) ✓

(b) Calculate the resistance of the resistor. (2)

$R = 10 \div 50 \times 10^{-3}$ ✓

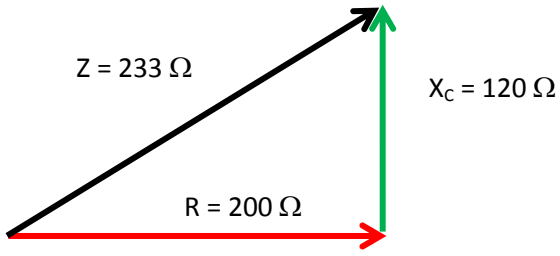
Resistance = 200 Ω ✓

(c) Calculate the reactance of the inductor. (2)

$XL = 6 \div 50 \times 10^{-3}$ ✓

Reactance = 120 Ω ✓

(d) Draw the impedance triangle for this circuit. Put values on for R, X_C, and Z. (4)



✓ ✓ ✓ ✓

	(e)	Calculate the phase angle.	(3)
	$\tan \phi = 120 \div 200 = 0.600$		✓
	$\phi = \tan^{-1} 0.600$		✓
	Phase angle = 31 degrees		✓
	(f)	Use your result to work out the power factor in this circuit.	(3)
	Power factor = cos f = cos 31		✓
	cos 31 = 0.857		✓
	Power factor = 0.857		✓
			16
		Total = 70 marks	

End of Examination

Now go back and check your work