<table>
<tr><td>Instructions for this assessment</td><td>This is a written assessment, and it will be assessing you on your knowledge of solving problems in low voltage a.c. circuits. The assessment may be conducted as a whole, or the parts separately or in combinations relevant to delivery schedule.

This assessment is in 15 parts:
1. Alternating Current Quantities
2. Phasor Diagrams
3. Single Element A.C. Circuits
4. RC and RL Series A.C. Circuits
5. RLC series circuits
6. Parallel a.c. Circuits
7. Power in an a.c. Circuit
8. Power Factor Improvement
9. Harmonics and Resonance Effect in a.c. Systems
10. Three Phase Systems
11. Three Phase Star Connections
12. Three Phase Four Wire Systems
13. Three Phase Delta Connections and Interconnected Systems
14. Energy and Power Requirements of ac Systems
15. Fault-loop Impedance

And is supported by
Assessment feedback</td></tr>
<tr><td>Submission instructions</td><td>On completion of this assessment, you are required to hand it to your Teacher/Assessor for marking.

Ensure you have written your name at the bottom of each page of this assessment.

It is important that you complete the assessment declaration when submitting the assessment.</td></tr>
</table>

Equation Reference Sheet

$$f = \frac{1}{T}$$

$$N = \frac{120f}{P}$$

$$f_o = \frac{1}{2\pi\sqrt{(LC)}}$$

$$v = V_m \, sin\theta$$

$$i = I_m \, sin\theta$$

$$V_{RMS} = 0.707 \, V_{MAX}$$

$$I_{RMS} = 0.707 \, I_{MAX}$$

$$I_L = I_P$$

$$V_L = \sqrt{3} \, V_P$$

$$V_L = V_P$$

$$I_L = \sqrt{3} \, I_P$$

$$pf = cos\,\emptyset$$

$$pf = \frac{R}{Z}$$

$$X_L = 2\pi f L$$

$$X_C = \frac{1}{2\pi f C}$$

$$Z = \sqrt{R^2 + X^2}$$

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

$$P = VI \, cos\,\emptyset$$

$$Q = VI \, sin\,\emptyset$$

$$S = VI$$

$$pf = \frac{P}{S}$$

$$P_T = W_1 + W_2$$

$$P_T = \sqrt{3} \, V_L I_L \cos\emptyset$$

$$S_T = \sqrt{3} \, V_L I_L$$

$$\emptyset = tan^{-1}\sqrt{3}\left(\frac{W_1 - W_2}{W_1 + W_2}\right)$$

$$I_T = \sqrt{{I_R}^2 + (I_C - I_L)^2}$$

Part 1: A.C. Quantities

(Time allowed - **15** minutes)

Instructions: For multiple choice questions, place an X in the appropriate box. For short answer questions, write the answer in the space provided. For questions that require calculations, show all working and write your answer in the space provided.

1. 1 The sine ratio of a right angled triangle is determined by:

Table 1 Multiple choice

Answer choices	Put X next to your answer
a) $\frac{\text{Opposite}}{\text{Adjacent}}$	
b) $\frac{\text{Adjacent}}{\text{Hypotenuse}}$	
c) $\frac{\text{Opposite}}{\text{Hypotenuse}}$	x

1. 2 The cosine ratio of a right angled triangle is determined by:

Table 2 Multiple choice

Answer choices	Put X next to your answer
a) $\frac{\text{Opposite}}{\text{Adjacent}}$	
b) $\frac{\text{Adjacent}}{\text{Hypotenuse}}$	x
c) $\frac{\text{Opposite}}{\text{Hypotenuse}}$	

1. 3 The tangent ratio of a right angled triangle is determined by:

Table 3 Multiple choice

Answer choices	Put X next to your answer
a) $\frac{\text{Opposite}}{\text{Adjacent}}$	x
b) $\frac{\text{Adjacent}}{\text{Hypotenuse}}$	
c) $\frac{\text{Opposite}}{\text{Hypotenuse}}$	

1.4 The **impedance triangle** equivalent of Pythagoras Theorem can be expressed mathematically as:

Table 4 Multiple choice

Answer choices	Put X next to your answer
a) $R^2 + X^2 = Z^2$	x
b) $R^2 - X^2 = Z^2$	
c) $Z^2 + X^2 = R^2$	
d) $Z^2 + R^2 = X^2$	

1.5 If a single-turn coil is rotated in a uniform magnetic field, the voltage generated will have the shape of a:

Table 5 Multiple choice

Answer choices	Put X next to your answer
a) sine wave	
b) square wave	x
c) sawtooth wave	
d) complex wave.	

1.6 The time taken to complete one full cycle of an a.c. waveform is known as the:

Table 6 Multiple choice

Answer choices	Put X next to your answer
a) time base	
b) period	x
c) peak value	
d) frequency.	

1. 7 The term **maximum value** in relation to a sine wave:

Table 7 Multiple choice

Answer choices	Put X next to your answer
a) is the highest value that the waveform reaches above zero	x
b) is the value between the highest and lowest values	
c) is 0.707 of the peak value	
d) varies with time between the maximum positive and negative values.	

1. 8 The term **peak to peak** value in relation to a sine wave:

Table 8 Multiple choice

Answer choices	Put X next to your answer
a) Is the highest value that the waveform reaches above zero	
b) Is the value between the highest and lowest values	
c) Is 0.707 of the peak value	
d) varies with time between the maximum positive and negative values	

1. 9 The term **instantaneous value** in relation to a sine wave:

Table 9 Multiple choice

Answer choices	Put X next to your answer
a) is the highest value that the waveform reaches above zero	
b) is the value between the highest and lowest values	
c) is 0.707 of the peak value	
d) varies with time between the maximum positive and negative values.	x

1. 10 The **average** value of one full cycle of an a.c. waveform is equal to:

Table 10 Multiple choice

Answer choices	Put X next to your answer
a) the peak-to-peak value	
b) the maximum value	
c) the RMS value	
d) zero	x

1. 11 The value of an a.c. waveform that has the **same heating effect** as an equivalent d.c. value is the:

Table 11 Multiple choice

Answer choices	Put X next to your answer
a) the peak-to-peak value	
b) the maximum value	
c) the RMS value	x
d) average value	

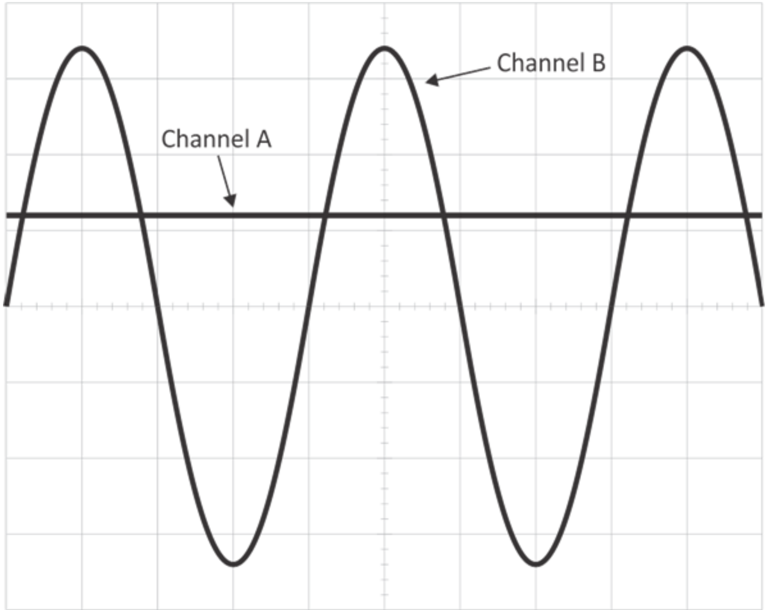
1. 12 A sine wave has a maximum voltage of 340 volts. Determine the instantaneous value of voltage at an angle of 210 degrees.

Instantaneous value = Maximum value xSin Ø= 340 Sin 210 =340 x (-0.5)= -170

170 V

v =

1. 13 The waveform below is displayed on the screen of an oscilloscope.



Both channels are set to 10V/div with a time base of 5ms/div.

Channel A is connected to a d.c. voltage source.

Channel B is connected to an a.c. voltage source.

- Determine the following.

Table 12 Multiple choice

		Answer
a.	Channel A voltage level:	50v
b.	Channel B maximum value:	25v
c.	Channel B RMS value:	17.gV
d.	Channel B peak-to-peak value:	70v
e.	Channel B period:	200ms
f.	Channel B frequency	5hZ
g.	Channel B instantaneous voltage at 45^0	10v

Part 2: Phasor Diagrams

(Time allowed - **10** minutes)

Instructions: For multiple choice questions, place an X in the appropriate box. For short answer questions, write the answer in the space provided. For questions that require calculations, show all working and write your answer in the space provided.

2. 1 Phasor diagrams provide a graphical means of adding a.c. waveforms together. A phasor must have:

Table 13 Multiple choice

Answer choices	Put X next to your answer
a) a magnitude, a direction, and a speed of rotation	
b) a magnitude and a speed of rotation	
c) a direction and a speed of rotation	
d) a magnitude and a direction	x

2. 2 When determining phase relationships (e.g. 'in-phase', 'out-of-phase', 'phase angle', 'leading', 'lagging'), phasors are assumed to have:

Table 14 Multiple choice

Answer choices		Put X next to your
a) linear velocity		
b) clockwise rotation		x
c) non-linear velocity		
d) anticlockwise rotation		

2. 3 When examining a phasor diagram, the shorter current phasor is drawn along the voltage phasor. This would indicate:

Table 15 Multiple choice

Answer choices	Put X next to your answer
a) the quantities are in phase	x
b) the quantities are out of phase	
c) the quantities are of the same value	

Answer choices	Put X next to your answer
d) there is a phase angle between the quantities	

2. 4 When examining a phasor diagram, phasors being out of phase is indicated by the phasors having:

Table 16 Multiple choice

Answer choices	Put X next to your answer
a) different lengths	
b) different thicknesses	
c) different arrow heads	
d) an angle between them	x

2. 5 When drawing a current phasor that is leading the reference voltage by 45 degrees it is drawn:

Table 17 Multiple choice

Answer choices	Put X next to your answer
a) in the same direction as the voltage phasor	
b) at an angle of 45 degrees above the horizontal	x
c) at 180 degrees to the voltage phasor	
d) at an angle of 45 degrees below the horizontal	

2. 6 In a 50Hz a.c. system, when drawing a current phasor that is lagging the reference voltage phasor by 5 milli seconds. it is drawn:

T=1/f= 1/50=0.02 sec

T=5/1000 = 0.005 sec

0.02 sec—1 full wave 360 degree

0.005 sec--- 360x0.005/0.02= 90 degree

Table 18 Multiple choice

Answer choices	Put X next to your answer

Answer choices	Put X next to your answer
a) in the same direction as the voltage phasor	
b) at 90 degrees upwards to the voltage phasor	
c) at 180 degrees to the voltage phasor	
d) at 90 degrees downwards to the voltage phasor.	x

2. 7 When drawing a phasor diagram the reference phasor is drawn:

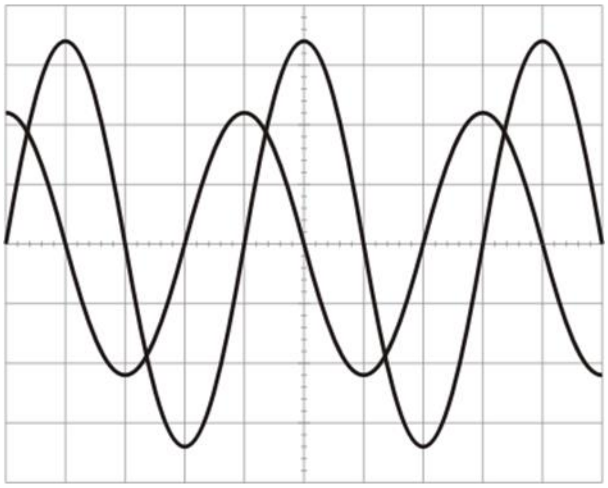
Table 19 Multiple choice

Answer choices	Put X next to your answer
a) along the vertical axis	
b) along the horizontal axis	x
c) where it will best fit on the page	
d) as a cross entering the page	

2. 8 When constructing a phasor diagram the voltage and current phasors are drawn with:

Table 20 Multiple choice

Answer choices	Put X next to your answer
a) open arrow heads for voltages and currents	
b) closed arrow heads for voltages and currents	x
c) open arrow heads for voltages and closed arrow heads for currents	
d) closed arrow heads for voltages and open arrow heads for currents	



2. 9 The oscilloscope below shows two waveforms.

What is the phase relationship between the two waveforms?

Table 21 Multiple choice

Answer choices	Put X next to your answer
a) The smaller waveform is leading the larger waveform by 45°	
b) The smaller waveform is lagging the larger waveform by 45°	x
c) The smaller waveform is leading the larger waveform by 90°	
d) The smaller waveform is lagging the larger waveform by 90°	

2. 10 Draw a phasor diagram of the currents displayed in the previous question, (freehand is acceptable) clearly indicating the approximate magnitudes, the angle between them and the reference phasor.

3. Single Element A.C. Circuits

(Time allowed - **15** minutes)

Instructions: For multiple choice questions, place an X in the appropriate box. For short answer questions, write the answer in the space provided. For questions that require calculations, show all working and write your answer in the space provided.

3.1 A set of 50 series connected, incandescent Christmas lights are connected in series to a 230V a.c. supply. As a purely resistive circuit, the angle of phase difference between the supply current and the voltage drops across each lamp will be:

Table 22 Multiple choice

Answer choices	Put X next to your answer
a) 0 degrees	x
b) 30 degrees	
c) 60 degrees	
d) 90 degrees	

3.2 Applications of resistive a.c. circuits include:

Table 23 Multiple choice

Answer choices	Put X next to your answer
a) water heaters and ceramic cooktops	x
b) fluorescent lamp ballasts and transformers	
c) transformers and water heaters	
d) ceramic cooktops and transformers	

3.3 In an a.c. circuit, a continuously changing current will cause an expanding and collapsing magnetic field which induces an emf that will oppose the original current. This type of opposition to current flow is called:

Table 24 Multiple choice

Answer choices	Put X next to your answer
a) inductance	x
b) capacitance	
c) inductive reactance	
d) capacitive reactance	

3.4 An inductor with an inductance of 2.1 Henry is connected to a 230V, 50Hz supply. Calculate the value of inductive reactance.

Xl = 2 Pi fL= 2.3.1416x50x2.1=659.7 Ohm

X_L [ ]

3.5 An inductor with an inductive reactance of 46 Ω is connected to a 230V, 50Hz supply. Determine the current that would flow.

I = 230/46=5 A

I_L = [ ]

3.6 If the frequency was increased for the inductor described in the previous question, the inductive reactance would

Table 25 Multiple choice

Answer choices	Put X next to your answer
a) remain the same	
b) decrease	
c) increase	x
d) Depend on the applied voltage.	

3.7 Applications of inductive a.c. circuits include:

Table 26 Multiple choice

Answer choices	Put X next to your answer
a) water heaters and ceramic cooktops	
b) fluorescent lamp ballasts and transformers	x
c) transformers and water heaters	
d) ceramic cooktops and transformers	

3.8 A capacitor with a capacitance of 3.3µF is connected to a 230V, 50Hz supply. What is the value of capacitive reactance?

c= 1/ 2 Pi fc= 1 / 2x3.1416x50x3.3x10^{-6}=10^{6} /2x3.1416x50x3.3=964.5 ohm

X_C =

3.9 Determine the capacitive reactance of a capacitor when a current of 10 A flows when connected to a 230V, 50Hz supply.

Xc= V/I= 230/10= 23 ohm

Xc=1 / 2 Pi fc= c=1/2 Pi f xc = 1/2 x3.1416x50x23 = 138,4 micro farad

I_C =

3.10 Capacitors are commonly used in a.c. circuits to:

Table 27 Multiple choice

Answer choices	Put X next to your answer
a) reduce power consumption	
b) limit fault capacity	
c) increase voltage surges	
d) improve power factor	x

Part 4: RC and RL Series A.C. Circuits

(Time allowed - **25** minutes)

Instructions: For multiple choice questions, place an X in the appropriate box. For short answer questions, write the answer in the space provided. For questions that require calculations, show all working and write your answer in the space provided.

4.1 The **total opposition** to current flow in an a.c. circuit is known as:

Table 28 Multiple choice

Answer choices	Put X next to your answer
a) resistance	
b) reactance	
c) impedance	x
d) inductance	

4.2 A single phase 230V 50 Hz circuit contains a 60Ω resistor in series with a 63µF capacitor.

a) Calculate circuit capacitive reactance (X_C)

xc= ½ pi fc= 10^6/ 2x3.1416x50x63 =50.5 ohm

X_C=

b) Calculate total circuit impedance (Z_T)

Z = sqrt R^2+x^2 sqrt 50.5^2+60^2=2550.25+3600= sqrt 6150.25

=78.4 ohm

Z_T=

c) Calculate total circuit current (I_T)

ir=V/Z = 230/78.4=2,93 A

I_T=

d) Calculate the voltage drop across the resistor (V_R)

Vr= Ix R = 2.93x60 =175.8 V

V_R=

e) Calculate the voltage drop across the capacitor (V_C)

Vc=I xc = 2.93x50.5=147.96 V

V_C=

4.3 When drawing a phasor diagram for a **series circuit** containing resistance and capacitance:

Table 29 Multiple choice

Answer choices	Put X next to your answer
a) the circuit current lags the applied voltage	
b) the circuit current leads the applied voltage	x
c) the resistor current is in phase with the applied voltage	
d) the capacitor current is out of phase with the applied voltage by 90°	

4.4 To comply with AS/NZS 3000, capacitors with a voltage rating up to 650V and a value greater than 0.5µF must be provided with a discharge path, so that when the capacitor is disconnected from the supply the capacitor terminal voltage is reduced to 50V or less within:

Table 30 Multiple choice

Answer choices	Put X next to your answer
a) 10 seconds	
b) 1 minute	x
c) 5 minutes	
d) 10 minutes	

4.5 Applications of capacitors in a.c. circuits include:

Table 31 Multiple choice

Answer choices	Put X next to your answer
a) water heaters and ceramic cooktops	
b) fluorescent lamp ballasts and transformers	
c) single phase motor starting and power factor correction	x
d) ceramic cooktops and transformers	

4.6 Adding capacitance to a power circuit or system that has a predominantly inductive load will:

Table 32 Multiple choice

Answer choices	Put X next to your answer
a) **increase** the angle of phase difference between the supply voltage and supply current	
b) **maintain** the angle of phase difference between the supply voltage and supply current	
c) **reduce** the angle of phase difference between the supply voltage and supply current	x
d) **reverse** the angle of phase difference between the supply voltage and supply current	

4.7 A single phase 230V 50Hz circuit contains a 100Ω resistor in series with a 1.5H inductor of negligible resistance.

a) Calculate the circuit inductive reactance (X_L).

xl=2 pi fl = 2.3.1416x50x1.5 = 471.24 ohm

X_L=	

b) Calculate the total circuit impedance (Z_T).

Z= Sqrt 100^2+471.24^2= sqrt 10000 =222067=481.73 ohm

Z_T=	

c) Calculate the circuit current (I_T).

Ir= 230v/481.73 ohm = 0.477 A

I_T=	

d) Calculate the voltage drop across the resistor (V_R)

Vr = IrxR = 0.477x 100 =47.7 V

V_R=	

e) Calculate the voltage drop across the inductor (V_L).

Vl = I xl = 0.477x 471.24 =224,99 V

V_L=	

4.8 The equivalent circuit of a practical inductor designed to operate at 50Hz consists of:

Table 33 Multiple choice

Answer choices	Put X next to your answer
a) a resistor in series with a coil	x
b) a resistor in parallel with a coil	
c) two equivalent coils in series	
d) two equivalent coils in parallel	

4.9 Transformers, motors and fluorescent light fittings are common inductive components in low voltage power circuits and systems. These types of components:

Table 34 Multiple choice

Answer choices	Put X next to your answer
a) **increase** the angle of phase difference between the supply voltage and supply current	x
b) **maintain** the angle of phase difference between the supply voltage and supply current	
c) **reduce** the angle of phase difference between the supply voltage and supply current	
d) **reverse** the angle of phase difference between the supply voltage and supply current	

Part 5: RLC series circuits

(Time allowed – 20 minutes)

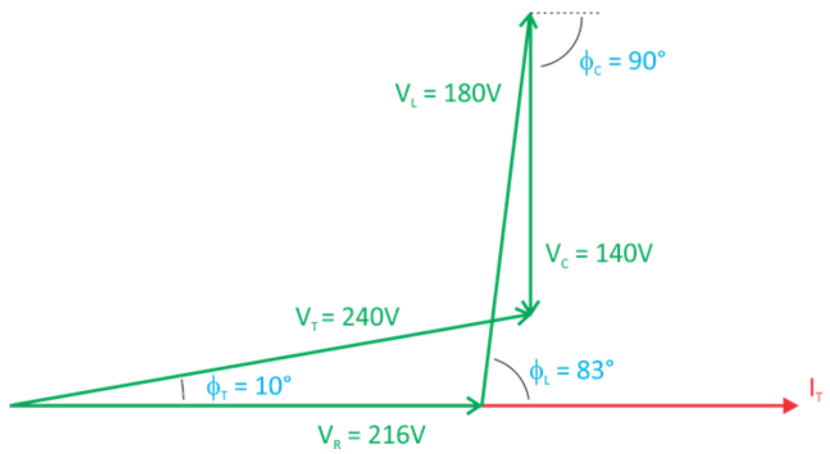
Instructions: For multiple choice questions, place an X in the appropriate box. For short answer questions, write the answer in the space provided. For questions that require calculations, show all working and write your answer in the space provided.

5.1 Care should be taken when measuring component voltages in a series RLC circuit as voltage drops across capacitors and inductors may substantially exceed the supply voltage due to:

Table 35 Multiple choice

Answer choices	Put X next to your answer
a) low power factor	
b) series resonance	
c) high reactance	
d) capacitive effects	x

5.2 The phasor diagram below shows the voltage drops and associated phase angles of a series a.c. circuit containing resistance, inductance and capacitance. Determine the **supply voltage** and the **circuit phase angle** from the diagram.



Supply Voltage = 240V

Circuit Phase Angle = 10

5.3 A **series** RLC circuit contains a 100Ω resistor, a 10μF capacitor and a 1.5H inductor with negligible resistance. The supply voltage is 230V 50Hz.

a) Calculate capacitive reactance (X_C)

xc = ½ Pi fc = 318.3 ohm

X_C=	

b) Calculate inductive reactance (X_L)

xl=2 pi fl= 2x3.1415x50x1.5= 471.2 ohm

X_L=	

c) Calculate total circuit impedance (Z_T)

Zt = sqt 100^2+(471.2-318.3}^{2}=213.36 ohm

Z_T=	

d) Calculate total current (I_T)

I= 230/213.36=1.077 A

I_T=	

e) Calculate the voltage drop across the resistor

Vr= 1.077x100= 107.7 v

V_R=	

f) Calculate the voltage drop across the inductor

vl=1.077x471.2=507.94 v

V_L=	

g) Calculate the voltage drop across the capacitor

vc=1.077x318.3=342.8 v

V_C=	

5.4 When calculating voltage drop in a cable, AS/NZS 3008 specifies values of "V_C" which are based on cable:

Table 36 Multiple choice

Answer choices	Put X next to your answer
a) impedance and capacitance values	x
b) capacitance and inductance values	
c) resistance and impedance values	
d) resistance and reactance values	

5.5 Inductors are often used instead of resistors in a.c. circuits to limit current flow. The advantage of using an inductor is that

Table 37 Multiple choice

Answer choices	Put X next to your answer
a) less power will be consumed	x
b) fault current is less likely to flow	
c) higher voltages can be tolerated	
d) the power factor will be higher	

5.6 In older style '*lead-lag*' fluorescent light fittings, one of the fluorescent tubes had a capacitor connected in series with the ballast. What **two (2)** purposes did this achieve?

Table 38 Multiple choice

Answer choices	Put X next to your answer
a) Improved power factor	x
b) Greater circuit impedance	
c) Reduced stroboscopic effect	x
d) Lower power consumption	

Part 6: Parallel a.c. Circuits

(Time allowed - 20 minutes)

Instructions: For multiple choice questions, place an X in the appropriate box. For short answer questions, write the answer in the space provided. For questions that require calculations, show all working and write your answer in the space provided.

6.1 A parallel RLC circuit contains a 220Ω resistor, a 3.3μF capacitor and a 1.5H inductor with negligible resistance. The supply voltage is 230V 50Hz

a) Calculate the capacitive branch impedance. (X_c)

c= ½ Pi fc =1/ 2 x 3.1416x50x3x10^{-6}=1061 ohm

X_C=	

b) Calculate inductive branch impedance (X_L)

Xl = 2 Pi fl =2.3.1416x50x1.5 =471.24 ohm

X_L=	

c) Calculate the capacitor branch current (I_c)

Ic=230/1061 =0.216 A

X_L=	

d) Calculate the Inductor branch current (I_L)

Il=230/471.24=0.488 A

I_L=	

e) Calculate the resistor branch current (I_R) and phase angle

Ir=230/220=1.045A

I_R=	

f) Calculate total circuit current (I_T) and phase angle.

I t= Sqt 1.045^2 + $(0..488-0.216)^2$ =1.079 A

I_T=	

g) Calculate the circuit impedance (Z_T)

Zt= V/It=230/1.079 =213.16 ohm	Z_T=	

h) Calculate the circuit phase angle

Angle = $\tan^{-1}$0.272/1.045 =14.56 degree	Angle	

6.2 Lighting, power, and appliance circuits connected to an electrical switchboard are connected in **parallel** with each other because each circuit needs to be supplied with the same:

Table 39 Multiple choice

Answer choices	Put X next to your answer
a) current	
b) voltage	x
c) impedance	
d) power	

Part 7: Power in an a.c. Circuit

(Time allowed - 10 minutes)

Instructions: For multiple choice questions, place an X in the appropriate box. For short answer questions, write the answer in the space provided. For questions that require calculations, show all working and write your answer in the space provided.

7.1 The **power factor** of an a.c. circuit can be defined as the ratio:

Table 40 Multiple choice

Answer choices	Put X next to your answer
a) $\frac{\text{resistance}}{\text{reactance}}$	x
b) $\frac{\text{resistance}}{\text{impedance}}$	
c) $\frac{\text{reactance}}{\text{impedance}}$	

7.2 The **phase angle** of an a.c. circuit can be defined as:

Table 41 Multiple choice

Answer choices	Put X next to your answer
a) $\cos^{-1}\left(\frac{\text{resistance}}{\text{impedance}}\right)$	x
b) $\cos^{-1}\left(\frac{\text{reactance}}{\text{impedance}}\right)$	
c) $\cos^{-1}\left(\frac{\text{resistance}}{\text{reactance}}\right)$	

7.3 Voltmeter and ammeter readings can be used in a single-phase circuit to measure:

Table 42 Multiple choice

Answer choices	Put X next to your answer
a) true power	
b) apparent power	x
c) reactive power	

Answer choices	Put X next to your answer
d) inductive power	

7.4 An a.c. wattmeter can be used in a single-phase circuit to measure:

Table 43 Multiple choice

Answer choices	Put X next to your answer
a) true power	x
b) apparent power	
c) reactive power	
d) inductive power	

7.5 When using an a.c. wattmeter to measure single-phase power consumption, the current coil must be connected:

Table 44 Multiple choice

Answer choices	Put X next to your answer
a) in series with the load	x
b) in parallel with the load	
c) in series with the voltage coil	
d) in parallel with the supply	

7.6 An ‘**accumulation**’ type kilowatt-hour meter is used to measure:

Table 45 Multiple choice

Answer choices	Put X next to your answer
a) true power consumed over a continuous period of time	x
b) apparent power consumed over a continuous period of time	
c) true power consumed during 30 minute periods throughout the day	
d) apparent power consumed during 30 minute periods throughout the day	

7.7 An ‘**interval**’ type kilowatt-hour meter measures:

Table 46 Multiple choice

Answer choices	Put X next to your answer
a) true power consumed over a continuous period of time	
b) apparent power consumed over a continuous period of time	
c) true power consumed during 30 minute periods throughout the day	x
d) apparent power consumed during 30 minute periods throughout the day	

Part 8: Power Factor Improvement

Part 9: Harmonics and Resonance Effect in a.c. Systems

(Time allowed - 10 minutes)

Instructions: For multiple choice questions, place an X in the appropriate box. For short answer questions, write the answer in the space provided. For questions that require calculations, show all working and write your answer in the space provided.

9.1 Where an electrical installation contains equipment designed to cause high-frequency switching of the load, this can cause the 50Hz supply waveform to be modified from the normal sinusoidal wave shape to a complex waveform. This is known as:

Table 54 Multiple choice

Answer choices	Put X next to your answer
a) harmonic displacement	
b) harmonic distortion	x
c) harmonic phase-shifting	
d) harmonic resonance	

9.2 Which **three (3)** of the following are the most likely to cause harmonics in an a.c. circuit?

Table 55 Multiple choice

Answer choices	Put X next to your answer
a) Variable frequency drives	x
b) Electric hot water systems	
c) Three-phase induction motors	
d) Electronic ballasts in fluorescent lighting	x
e) Inverters used with photovoltaic grid-connected equipment	x

9.3 To overcome issues associated with 3rd order harmonics and their odd multiples, it is common to install:

Table 56 Multiple choice

Answer choices	Put X next to your answer
a) phase sequence indicators on the main switchboard	
b) stabilisation equipment to prevent a 'leading' power factor	
c) shielded or armoured cable to circuits supplying electric motors	
d) a neutral conductor with a capacity greater than the associated active conductors	x

9.4 Harmonic waveforms can be visualised and the harmonic order determined using:

Table 57 Multiple choice

Answer choices	Put X next to your answer
a) phase sequence indicators	
b) a true RMS voltmeter	
c) a power analyser	x
d) an RCD tester	

9.5 Harmonics can be reduced in an a.c. power system through the use of:

Table 58 Multiple choice

Answer choices	Put X next to your answer
a) inductive and capacitive filters	x
b) shielded or armoured cable	
c) waveform stabilisers	
d) voltage regulators	

9.6 Resonance occurs in an a.c. circuit when **capacitive reactance** and **inductive reactance** are:

Table 59 Multiple choice

Answer choices	Put X next to your answer
a) zero	
b) minimum	
c) equal	x
d) maximum	

9.7 Which of the following is true for a **series** a.c. circuit at resonance?

Table 60 Multiple choice

Answer choices	Put X next to your answer
a) Circuit impedance and circuit current will both be at a minimum	
b) Circuit impedance and circuit current will both be at a maximum	
c) Circuit impedance will be at a minimum and circuit current will be at a maximum	x
d) Circuit impedance will be at a maximum and circuit current will be at a minimum	

9.8 Which of the following is true for a **parallel** a.c. circuit at resonance?

Table 61 Multiple choice

Answer choices	Put X next to your answer
a) Circuit impedance and circuit current will both be at a minimum	
b) Circuit impedance and circuit current will both be at a maximum	
c) Circuit impedance will be at a minimum and circuit current will be at a maximum	
d) Circuit impedance will be at a maximum and circuit current will be at a minimum	x

9.9 Care should be taken when working on **series** resonant a.c. circuits due to the danger of:

Table 62 Multiple choice

Answer choices	Put X next to your answer
a) high circulating currents flowing between inductive and capacitive components	x
b) high voltages that may be present across inductive and capacitive components	
c) high let-through energy associated with inductive and capacitive components	
d) high power dissipation from inductive and capacitive components	

9.10 Care should be taken when working on **parallel** resonant a.c. circuits due to the danger of:

Table 63 Multiple choice

Answer choices	Put X next to your answer
a) high circulating currents flowing between inductive and capacitive components	
b) high voltages that may be present across inductive and capacitive components	x
c) high let-through energy associated with inductive and capacitive components	
d) high power dissipation from inductive and capacitive components	

9.11 Capacitors connected across the supply terminals of electrical equipment can appear as a low impedance path for high frequency *Ripple Control* signals used to control street lighting and off-peak systems. To prevent these control signals from being absorbed by these capacitors, blocking inductors need to be connected:

Table 64 Multiple choice

Answer choices	Put X next to your answer
a) in series with the load	
b) in parallel with the load	x
c) in series with the capacitor	
d) in parallel with the capacitor	

Topic 10:Three Phase Systems

(Time allowed - 10 minutes)

Instructions: For multiple choice questions, place an X in the appropriate box. For short answer questions, write the answer in the space provided. For questions that require calculations, show all working and write your answer in the space provided.

10.1 A multiphase supply system is simply two or more single-phase a.c. voltages:

Table 65 Multiple choice

Answer choices	Put X next to your answer
a) that are connected in series	
b) that are connected in parallel	
c) with an electrical phase displacement	x
d) with a mechanical phase displacement	

10.2 In Australia, the colours used to represent the phases of a three-phase electrical supply system are:

Table 66 Multiple choice

Answer choices	Put X next to your answer
a) Red, White, Blue	x
b) Red, Yellow, Blue	
c) Red, Black, Green/Yellow	
d) Brown, Blue, Green/Yellow	

10.3 One advantage of a three-phase alternator over a single-phase alternator is that:

Table 67 Multiple choice

Answer choices	Put X next to your answer
a) two system voltages are available	x
b) less insulation if required per phase	
c) single-phase motors will run with less vibration	
d) single-phase appliances will be more efficient	

10.4 In terms of being the most **efficient** and **economical**, the preferred number of phases for electrical power generation, transmission and distribution is:

Table 68 Multiple choice

Answer choices	Put X next to your answer
a) one	
b) two	
c) three	x
d) four	

10.5 A three-phase supply is generated in an alternator by a rotating magnetic field cutting through three separate phase windings that are arranged around the stator and displaced from each other by:

Table 69 Multiple choice

Answer choices	Put X next to your answer
a) 60° electrical	
b) 90° electrical	
c) 120° electrical	x
d) 180° electrical	

10.6 A three-phase alternator generates a phase voltage with a maximum value of 325V. Calculate the RMS value of this waveform.

Vrms= Vmax/Sqrt 2 = 325/1.4142=229.8V

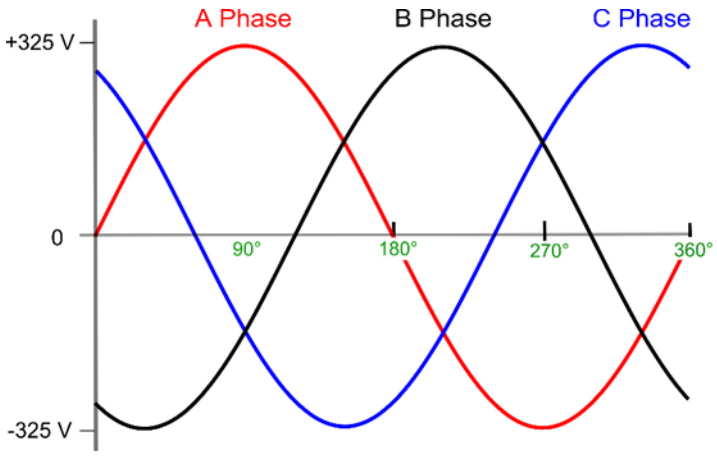
V=	

10.7 The ‘**phase sequence**’ of a three-phase supply may be defined as:

Table 70 Multiple choice

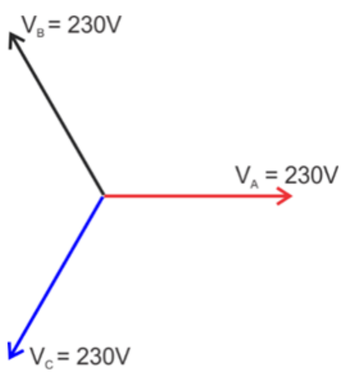
Answer choices	Put X next to your answer
a) the process of changing equipment from star to delta	
b) the method of connecting each phase at a multiphase socket outlet	
c) the order in which consumer mains are connected at the point of supply	
d) the order in which each supply phase voltage reaches a positive peak value	x

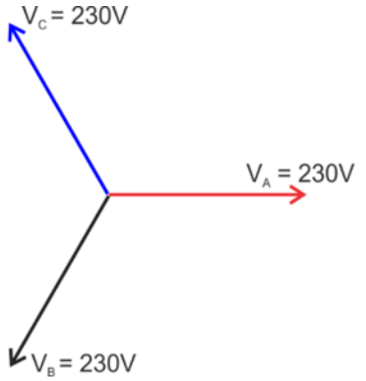
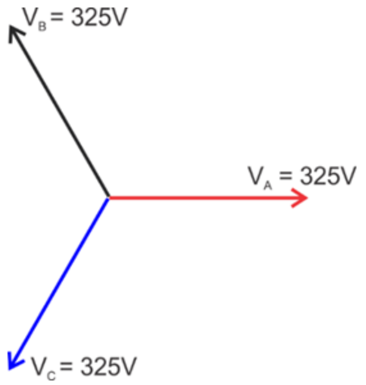
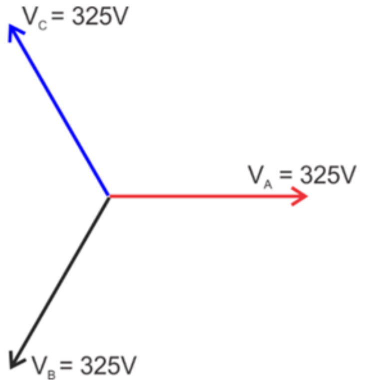
10.8 The diagram below shows the output waveforms of a 3 phase 230/400V generator.



Which of the following phasor diagrams is a true representation of the generator phase voltages?

Table 71 Multiple choice

Answer choice	Put X next to your answer
 a)	

Answer choice	Put X next to your answer
b) 	x
c) 	
d) 	

Part 11:Three Phase Star Connections

(Time allowed - 10 minutes)

Instructions: For multiple choice questions, place an X in the appropriate box. For short answer questions, write the answer in the space provided. For questions that require calculations, show all working and write your answer in the space provided.

11.1 The phase relationship between the **phase voltage** and the **line voltage** of a STAR connected system is:

Table 72 Multiple choice

Answer choices	Put X next to your answer
a) 0°	
b) 30°	x
c) 90°	
d) 120°	

11.2 The phase relationship between the **phase current** and the **line current** of a STAR connected system is:

Table 73 Multiple choice

Answer choices	Put X next to your answer
a) 0°	
b) 30°	x
c) 90°	
d) 120°	

11.3 A three-phase STAR connected load has a phase voltage of 230V and a phase current of 10A. Calculate the following parameters of the connection.

(a) Line voltage

400V

V_L=	

(b) Line current.

10A

I_L=	

11.4 Select all valid statements for a balanced load connected to a three phase system:

Table 74 Multiple choice

Answer choices	Put X next to your answer
a) Phase currents will be the same.	x
b) Phase power factors will be the same.	
c) If connected, the neutral current will be zero.	
d) There must be a neutral connected.	

11.5 One of the phase windings of a STAR connected alternator is accidently connected in reverse during manufacture. When the alternator is run up to the specified speed and tested with a multimeter on the voltage range:

Table 75 Multiple choice

Answer choices	Put X next to your answer
a) all phase voltages and line voltages will appear to be correct	
b) the line voltages will appear to be correct but the phase voltages will be incorrect	
c) the phase voltages will appear to be correct but the line voltages will be incorrect	x
d) all phase voltages and line voltages will appear to be incorrect	

11.6 Which of the following would be considered a balanced load?

Select all the correct answers.

Table 76 Multiple choice

Answer choices	Put X next to your answer
a) 3 phase induction motor.	x
b) A domestic installation with a 3 phase supply.	
c) 3 phase commercial oven.	x
d) A public toilet block with 4 luminaries.	

Part 12: Three Phase Four Wire Systems

(Time allowed - 5 minutes)

Instructions: For multiple choice questions, place an X in the appropriate box. For short answer questions, write the answer in the space provided. For questions that require calculations, show all working and write your answer in the space provided.

12.1 A three-phase consumer main is rated at 100A per phase. The installation consists predominantly of linear single-phase loads (i.e. very low harmonics). The minimum current rating for the neutral conductor is:

Table 77 Multiple choice

Answer choices	Put X next to your answer
a) 50A	
b) 100A	x
c) 200A	
d) 300A	

12.2 According to AS/NZS 3008, the voltage drop in an **unbalanced** three-phase circuit can be conservatively calculated by assuming a balanced three-phase load and using:

Table 78 Multiple choice

Answer choices	Put X next to your answer
a) the current in the least loaded phase	
b) the current in the heaviest loaded phase	
c) the total current of all three phases combined	
d) the out-of-balance current flowing in the neutral conductor	x

Part 13: Three Phase Delta Connections and Interconnected Systems

(Time allowed - 15 minutes)

Instructions: For multiple choice questions, place an X in the appropriate box. For short answer questions, write the answer in the space provided. For questions that require calculations, show all working and write your answer in the space provided.

13.1 The phase relationship between the **phase voltage** and the **line voltage** of a DELTA connected system is:

Table 79 Multiple choice

Answer choices	Put X next to your answer
a) 0°	x
b) 30°	
c) 90°	
d) 120°	

13.2 The phase relationship between the **phase current** and the **line current** of a DELTA connected system is:

Table 80 Multiple choice

Answer choices	Put X next to your answer
a) 0°	
b) 30°	x
c) 90°	
d) 120°	

13.3 A three-phase DELTA connected load has a phase voltage of 400V and a phase current of 10A. Calculate the following parameters of the connection.

(a) Line voltage

400 V

V_L=	

(b) Line current.

17.321A

I_L=	

13.4 An '**open delta**' connection allows two single-phase transformers to be connected to a three-phase supply. While this provides a cheaper alternative to a three-phase transformer, the total power available compared to using three transformers will be limited to:

Table 81 Multiple choice

Answer choices	Put X next to your answer
a) 33.3%	
b) 45.5%	
c) 57.7%	x
d) 66.6%	

13.5 When connecting the secondary windings of a three-phase transformer in DELTA, care must be taken to ensure that the phase relationships are maintained. If one of the secondary windings is accidently reversed:

Table 82 Multiple choice

Answer choices	Put X next to your answer
a) the transformer impedance will increase	
b) excessive current will be supplied to the load	x
c) the primary voltage will exceed the transformer rating	
d) a high circulating current will flow within the secondary	

13.6 Which of the following are examples of '**loads**' in an electrical power system?

Select ALL correct answers.

Table 83 Multiple choice

Answer choices	Put X next to your answer
a) Switchboard	
b) Single phase motor	x
c) Circuit-breaker	
d) Industrial oven	x
e) Hot water system	x
f) Three phase isolator	

13.7 Draw a circuit diagram showing a star connected transformer (secondary windings only) supplying a delta connected load – label the diagram to show: Line current, Phase current, Line voltage and Phase voltage

Part 14: Energy and Power Requirements of ac Systems

(Time allowed - 10 minutes)

Instructions: For multiple choice questions, place an X in the appropriate box. For short answer questions, write the answer in the space provided. For questions that require calculations, show all working and write your answer in the space provided.

14.1 A kWh meter is used to measure **electrical energy** to:

Table 84 Multiple choice

Answer choices	Put X next to your answer
a) check that equipment is operating at maximum efficiently	
b) determine how much to charge for electricity	x
c) help with maintenance planning	
d) assist with fault finding.	

14.2 An **existing** electrical installation is to have a new submain installed to supply additional equipment. The most practical way of checking that the consumer mains have enough capacity for the extra load is by:

Table 85 Multiple choice

Answer choices	Put X next to your answer
a) calculating the new total load on the installation	x
b) measuring the maximum demand at the main switchboard	
c) estimating the current in the mains during peak supply periods	
d) installing a new main switch with a greater current-carrying capacity	

14.3 A **true power** measurement of a three-phase installation will indicate the power consumed by:

Table 86 Multiple choice

Answer choices	Put X next to your answer
a) resistive components	x
b) inductive components	
c) capacitive components	
d) all circuit components	

14.4 As the power factor of a load is usually unknown and can be changing constantly, transformers are usually rated in:

Table 87 Multiple choice

Answer choices	Put X next to your answer
a) kW	
b) kVA	x
c) kVAr	
d) Z%	

14.5 **Reactive power** in an electrical installation does no useful work and is usually managed using power factor correction equipment. Reactive power is measured in:

Table 88 Multiple choice

Answer choices	Put X next to your answer
a) W	
b) VA	
c) VAr	x
d) Z%	

14.6 The total power of a three-phase circuit can be measured using a single-phase wattmeter provided that:

Table 89 Multiple choice

Answer choices	Put X next to your answer
a) the load is balanced	x
b) the load is unbalanced	
c) the neutral is disconnected	
d) the voltage coil is connected between phases	

14.7 The '**two wattmeter method**' can be used to measure the power consumed by an unbalanced or a balanced three-phase load and with a balanced load will also allow you to calculate the circuit:

Table 90 Multiple choice

Answer choices	Put X next to your answer
a) impedance	
b) voltage drop	
c) power factor	x
d) maximum demand	

14.8 Power Factor in a three phase commercial installation is usually improved using a controlled switched bank of:

Table 91 Multiple choice

Answer choices	Put X next to your answer
a) Capacitors	x
b) Inductors	
c) Resistors	
d) Transformers	

14.9 The following table provides a summary of meter types approved by *Ausgrid* for Type 5 and Type 6 metering installations.

Prefix	Program	19	60	21	61	20	62	63	23	64	65	66	67	25	26	27	29
	Category	Import Only		Import Export (NET)		Element 1 Import Only Element 2 OPHW			Element 1 Import Export Element 2 Controlled Load			OPHW Element 2		Gross Generation Meter Programs			
						OP1 OP2	OP1	OP2	OP1 OP2	OP1	OP2	OP1	OP2				
AMS	B1	FLAT RATE SINGLE PHASE															
HLA																	
AMT	B3	FLAT RATE THREE PHASE															
HLE																	
AMG	E1	✓															
PRS		✓		✓													
EEL		✓		✓										✓			
ECA	E1c		✓		✓												
PRT	E2					✓			✓								
AMJ						✓			✓						✓	✓	✓
ECJ	E2c						✓	✓		✓	✓	✓	✓				
EET	E3	✓		✓										✓			
PRW		✓		✓													
AMX		✓		✓										✓			
LGC		✓		✓										✓			
ECP	E3c		✓		✓												

Which of the following is the most suitable for a single-phase installation with off-peak hot water?

Table 92 Multiple choice

Answer choices	Put X next to your answer
a) E1	
b) E2	
c) E3	
d) E3c	

Part 15: Fault-loop Impedance

(Time allowed - 5 minutes)

Instructions: For multiple choice questions, place an X in the appropriate box. For short answer questions, write the answer in the space provided. For questions that require calculations, show all working and write your answer in the space provided.

15.1 The term '**fault-loop impedance**' refers to the impedance of:

Table 93 Multiple choice

Answer choices	Put X next to your answer
a) the arc that is produced during a fault	
b) the low voltage overhead supply mains	
c) the Electricity Distributor's supply transformer	
d) the circuit formed during a fault between live parts and earth	x

15.2 Fault-loop impedance is usually determined using AS/NZS 3000, however for larger cables such as mains and submains it can be determined using the relevant tables from AS/NZS 3008 that provide values of:

Table 94 Multiple choice

Answer choices	Put X next to your answer
a) resistance and impedance	x
b) resistance and reactance	
c) reactance and impedance	
d) resistance and inductance	

15.3 When measuring the fault-loop impedance on a live circuit protected by a 20A Type 'C' circuit-breaker, the maximum value permitted is: Table 8.1

Table 95 Multiple choice

Answer choices	Put X next to your answer
a) 0.9 Ω	x
b) 1.5 Ω	
c) 2.1 Ω	
d) 2.9 Ω	

15.4 An ohmmeter is used to measure the resistance of the active-earth loop (R_{phe}) of a circuit supplying a hot water heater. The circuit is run in 2.5mm^2 TPS and is protected by a 16A Type 'C' circuit-breaker. The maximum value of resistance permitted is:

Table 96 Multiple choice

Answer choices	Put X next to your answer
a) 0.6 Ω	
b) 1.0 Ω	
c) 1.2 Ω	
d) 1.9 Ω	x

15.5 The earth fault-loop impedance of a lighting circuit needs to be tested when there is **no supply available**. To prepare for this test, which two conductors need to be shorted together?

Table 97 Multiple choice

Answer choices	Put X next to your answer
a) Active and Neutral	
b) Active and Switch wire	
c) Active and Earth	
d) Neutral and Earth	