education

Department:
Education
REPUBLIC OF SOUTH AFRICA

NATIONAL SENIOR CERTIFICATE

GRADE 12

ELECTRICAL TECHNOLOGY

NOVEMBER 2009

MEMORANDUM

MARKS: 200

This memorandum consists of 13 pages and 1 formula sheet.

QUESTION 1: TECHNOLOGY, SOCIETY AND THE ENVIRONMENT

1.1 Air pollution caused by generation of electricity, coal emissions, etc.✓✓
Water, waste due to generation of electricity and disposable of energy devices✓✓ (4)

1.2 Marketing✓
Communication✓
Presentation ✓
Financial literacy
Costing of materials etc. (Any three) (3)

1.3 Inclusitivity✓
Physical access ✓
Human rights✓
Social justice (Any three) (3)
[10]

QUESTION 2: TECHNOLOGICAL PROCESS

2.1.1 Poor sound quality of the radio ✓✓ (2)

2.1.2

INPUT✓	→	PROCESS✓	→	OUTPUT✓
Sound (waves)✓		Amplification process✓		Amplified sound waves✓

(6)

2.1.3 The circuit connections and assembling should be correct✓
The amplifier should provide an audible sound to meet the needs of the elderly people.✓
Correct operation
The device circuit should be packaged in a portable way.
(Any relevant answer is correct.) (2)
[10]

QUESTION 3: OCCUPATIONAL HEALTH AND SAFETY

3.1 Make sure a soldering stand is used to support the iron when not in use to prevent burn damage and possible fire. ✓✓ (more options) (2)

3.2 Make sure no physical contact is made with the chemicals.
It will damage clothes and may also cause skin damage. ✓✓ (2)

3.3 Inspect the supply cord to make sure that there are no exposed conductors which could lead to a short circuit and possible shock.
Inspect the casing of the drilling machine to ensure it is earthed to give electrical and mechanical protection✓✓ (2)

3.4 Working on a live system with exposed conductors. ✓✓
Working with portable electric equipment that is not insulated correctly.
(more options) (2)

3.5 Make surethat the meter is connected in parallel in the circuit. ✓
Make sure the lead connections are connected into the correct socket of the meter ✓ (2)

[10]

QUESTION 4: THREE-PHASE AC GENERATION

4.1 A three-phase system is more versatile than a single-phase system as it can be connected in star or delta. ✓ (many others) (1)

4.2 A single-phase motor has a lagging power factor✓ as it consists of coils which are inductive. Current through an inductor connected to an AC supply lays the applied voltage ✓✓ (3)

4.3

$$V_{Ph} = 380\ V$$
$$\therefore V_L = 380\ V$$
$$I_{Ph} = 12\ A$$

$$I_L = \sqrt{3} I_{Ph}$$
$$= \sqrt{3} x 12$$
$$= 20{,}78\ A$$

4.3.1

$$P_L = \sqrt{3} V_L I_L \cos\theta \quad ✓$$
$$= \sqrt{3} x 380 x 20{,}78 x \cos 25 \quad ✓$$
$$= 12{,}395\ kW \quad ✓$$

(3)

4.3.2

$$S = \frac{P}{\cos\theta} \checkmark$$

$$= \frac{12{,}395}{\cos 25^o} \checkmark$$

$$= 13{,}67\ kVA \checkmark$$

(3)

[10]

QUESTION 5: R, L AND C CIRCUITS

5.1.1 Z ✓ (1)

5.1.2 X_C ✓ (1)

5.1.3 L ✓ (1)

5.2.1

$$V_T = \sqrt{V_R{}^2 + V_L{}^2} \checkmark$$

$$= \sqrt{30^2 + 40^2} \checkmark$$

$$= 50\ V \checkmark$$

(3)

5.2.2

$$\theta = \cos^{-1}\frac{V_R}{V_T} \checkmark$$

(Not the only method)

$$= \cos^{-1}\frac{30}{50} \checkmark$$

$$= 53{,}13^\circ \checkmark$$

(3)

5.2.3

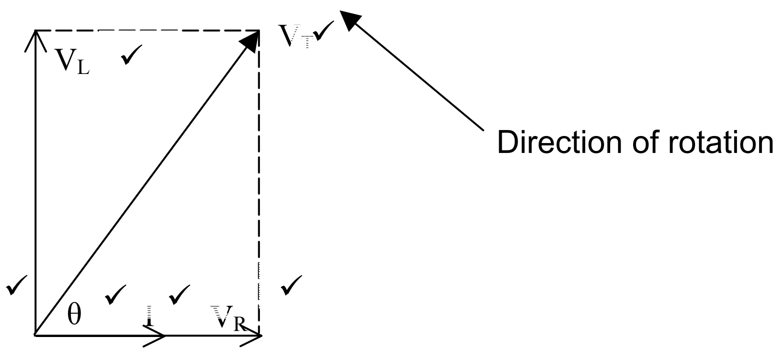
$$Z = \frac{V_T}{I_T} \checkmark$$

$$= \frac{50}{3} \checkmark$$

$$= 16{,}67\,\Omega \checkmark$$

(3)

5.2.4



(6)

5.3.1 $X_L = 2\pi fL$ ✓

$= 2\ \pi\ x\, 50\ x\, 0.1$ ✓

$= 31{,}416\ \Omega$ ✓

$I_L = \dfrac{V}{X_L}$ ✓

$= \dfrac{100}{31{,}416}$ ✓

$= 3{,}18\ A$ ✓

Alternative

✓
✓

$I_L = \dfrac{V}{2\pi FL}$ ✓

$= \dfrac{100}{2\pi x 50\ x 0{,}1}$ ✓

$= 3{,}18\ A$ ✓

✓

(6)

5.3.2 $I_R = \dfrac{V}{R}$ ✓

$= \dfrac{100}{20}$ ✓

$= 5\ A$ ✓

(3)

5.3.3 $I_T = \sqrt{I_R{}^2 + (I_C - I_L)^2}$ ✓

$= \sqrt{5^2 + (4.71 - 3.18)^2}$ ✓

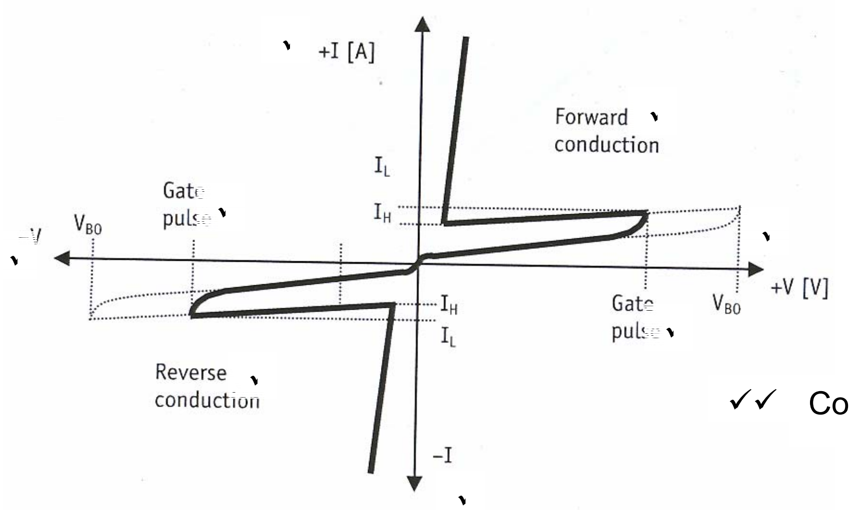
$= 5{,}23\ A$ ✓

(3)
[30]

QUESTION 6: SWITCHING AND CONTROL CIRCUITS

6.1 If a rising voltage is applied to a DIAC it acts like an open switch.✓ When the DIAC's trigger voltage is reached, the internal resistance of the DIAC breaks down✓ allowing the DIAC to conduct.✓ It operates in both directions. When the current falls below the holding current, it switches off.✓ A DIAC switches on at the same time in both directions. (4)

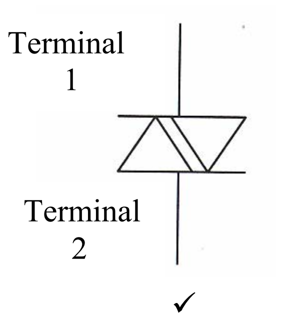
6.2



✓✓ Correct shape

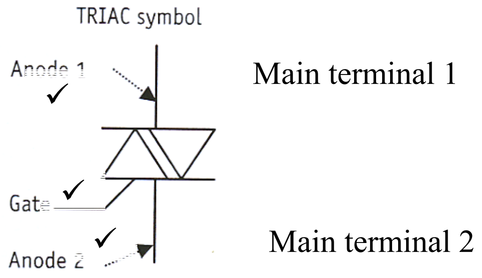
(10 x 0,5) (5)

6.3 6.3.1 ✓



(2)

6.3.2



(3)

6.4 **Switched on**. A positive potential must be applied to the anode terminal. The SCR will now be in a state ready to conduct.✓ When the correct positive potential is applied to the gate the SCR will begin to conduct. ✓

Switched off. The current flowing through the SCR must be reduced below the holding value. ✓ Remove or reverse the potential across the SCR. ✓ (4)

6.5 When the triggering circuit has no capacitor in it, the triggering signal will not be delayed by a time constant.✓ When the voltage level at the gate reaches the triggering level, the SCR will be fired.✓ Because the sinusoidal supply reaches its maximum at 90°, any value after 90° that could trigger the SCR has already occured before 90°. ✓✓ (4)

6.6 The advantage of the TRIAC and SCR in power control is that they have low power loss for the amount of power that is controlled.✓ Current control is also smooth, fast and accurate. ✓ (2)

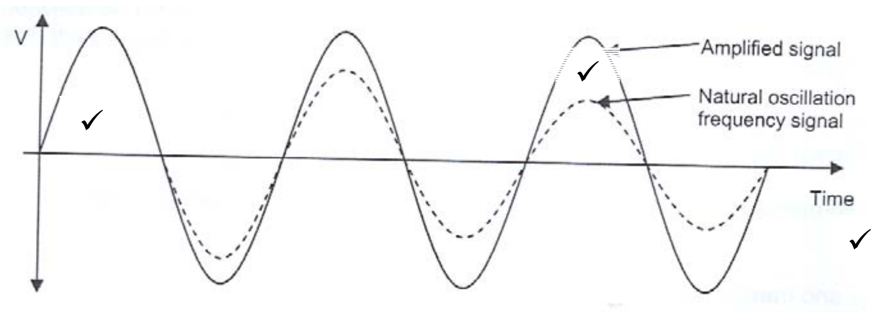
6.7 The TRIAC has full-wave control in AC applications, the SCR has only half-wave control. ✓ (1)

[25]

QUESTION 7: AMPLIFIERS

7.1 Positive feedback means that the output signal is added to the input signal.✓ The magnitude of the signal of that particular frequency is increased,✓ and all other frequency signals will diminish. ✓ (3)

7.2



The electrical signal that the oscillator produces is called the natural oscillation frequency. ✓Natural oscillation diminishes in amplitude and disappears due to a lack of positive feedback✓ (6)

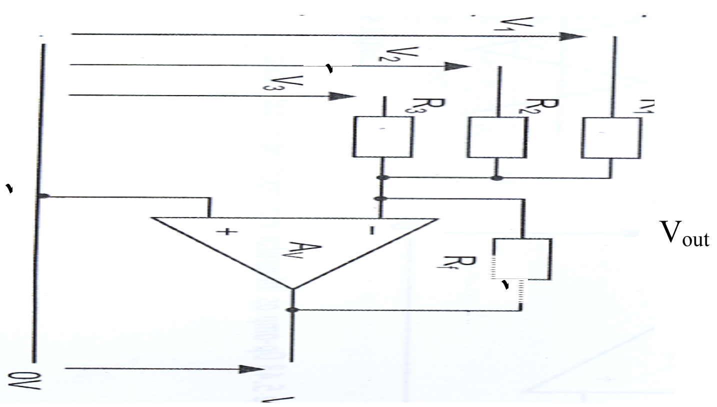
7.3

7.3.1 The following are the changes in the response curve with negative feedback as compared to no negative feedback.
The gain is smaller ✓
The characteristic curve is flatter ✓
Bandwidth increased ✓
Cut-off frequencies are further apart ✓ (4)

7.3.2 Yes, ✓ the ideal is to have an amplifier with a flat response curve✓. (2)
✓

7.4

7.4.1



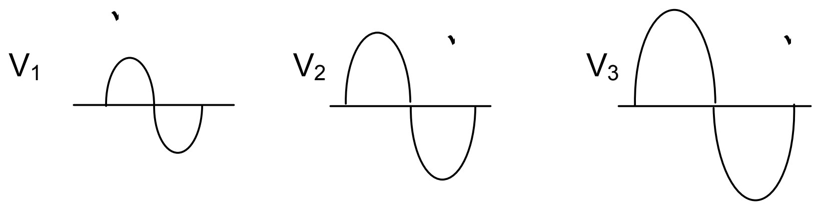
(3)

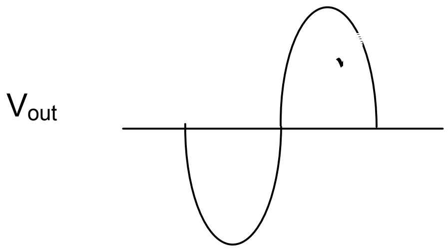
7.4.2 $V_T = -(V_1 + V_2 + V_3)$ ✓

$= -(0{,}5 + 1 + 1{,}5)$ ✓

$= -3$ ✓ (3)

7.4.3





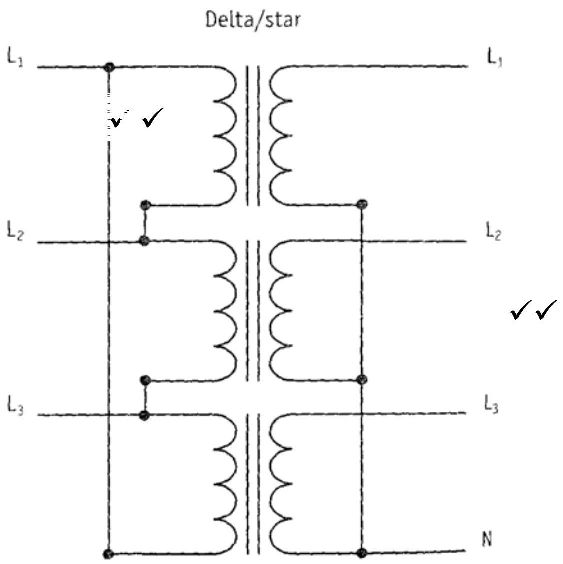
(Any correctly interpreted answer)

(4)
[25]

QUESTION 8: THREE-PHASE TRANSFORMERS

8.1 Iron losses✓
Copper losses✓ (2)

8.2



(4)

8.3.1

$$S = \frac{P}{PF} \checkmark$$
$$= \frac{10\,000}{0{,}8} \checkmark$$
$$= 12{,}5\ kVA \checkmark$$

(3)

8.3.2
$$I_{L(S)} = \frac{P}{\sqrt{3}V_{LS}\cos\theta} \checkmark$$
$$= \frac{10\,000}{\sqrt{3}x400x0,8} \checkmark \checkmark$$
$$= 18,04\ A$$
(3)

8.3.3
$$I_{Ph(S)} = I_{L(S)} \checkmark$$
$$= 18,04\ A \checkmark \checkmark$$
(3)
[15]

QUESTION 9: LOGIC CONCEPTS AND PLC'S

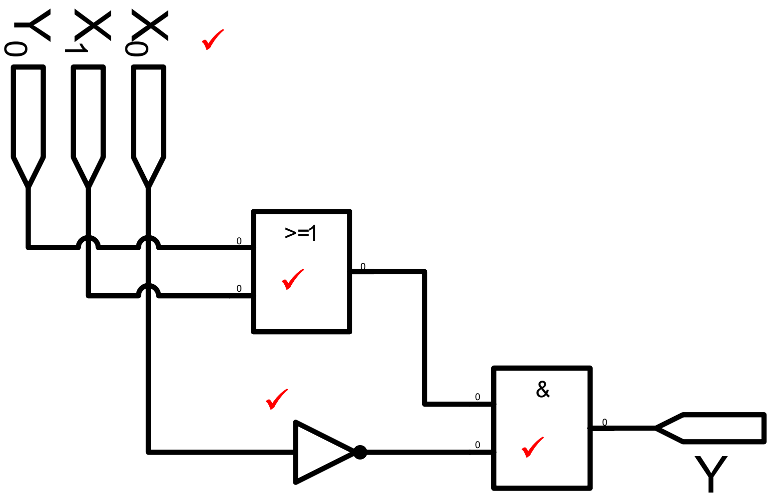
9.1 Synchronous counters✓
Asynchronous counters✓
(Also known as clocked and unclocked counters) (2)

9.2 Monostable✓
Astable✓
Bistable✓ (3)

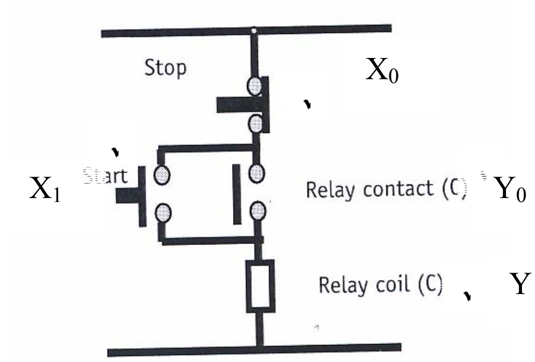
9.3 Positive logic✓
Negative logic✓ (2)

9.4 Fewer components such as contactors are subject to wear because less of these items are used✓. Additionally units have built-in diagnostic functions. (1)

9.5



Alternatively accept the Direct-on-line starter



(4)

9.6

9.6.1 F = A.$\bar{B}$.C✓ + $\bar{A}$.B.C✓ + A.B.$\bar{C}$✓ + A.B.C✓ (4)

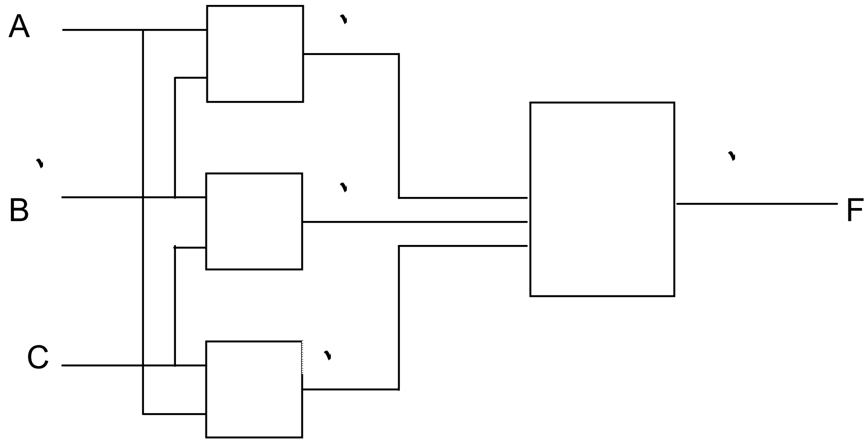
9.6.2

	$\bar{A}\,\bar{B}$	$\bar{A}\,B$	$A\,B$	$A\,\bar{B}$
$\bar{C}$			1	
C		1	1	1

F = A.B + B.C + A.C

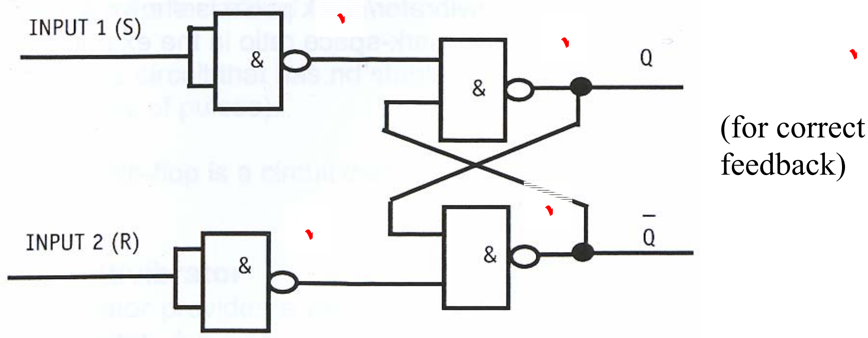
(5)

9.6.3



(5)

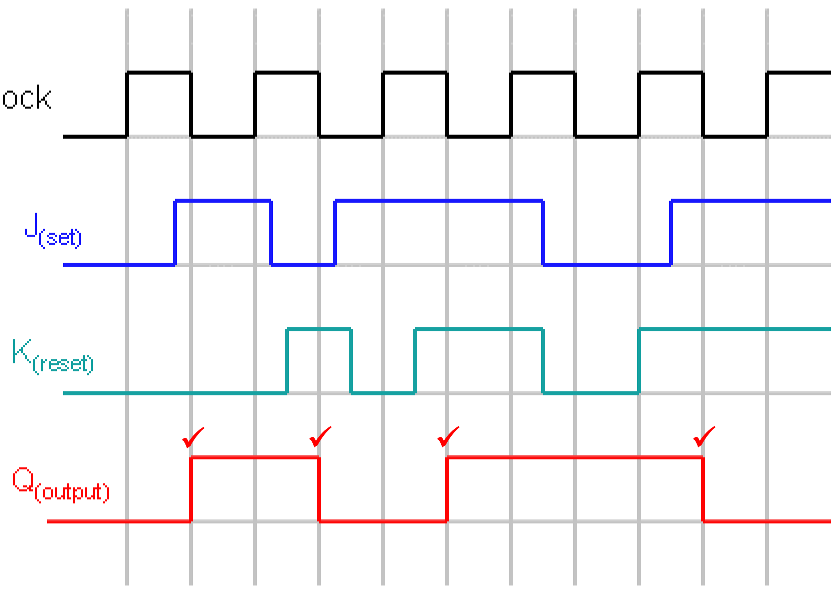
9.7



(for correct feedback)

(5)

9.8



All changes to output Q must be in line with the enabling clock pulse no matter when input changes. Note the order of change. First either J or K is set or reset, then the clock pulse enables the output to change accordingly. (4)

[35]

QUESTION 10: THREE-PHASE MOTORS AND CONTROL

10.1

10.1.1 Earth Resistance Test✓
Field Coil Continuity / Resistance Test✓
(Any acceptable electrical test) (2)

10.1.2 Check bearings for smooth operation✓
Check housing for cracks✓
(Any acceptable mechanical check) (2)

10.2

10.2.1 Field Coil Windings✓

10.2.2 Bearing and / or Bearing Housing ✓
(Answer has to contain reference to the bearing)

10.2.3 Rotor / Squirrel-Cage Rotor or similar answer✓

10.2.4 Stator / Housing✓ (4)

10.3 A three-phase alternating voltage supply is connected across the stator windings in either star or delta. ✓
Due to the phase difference of the current in the stator windings a rotating magnetic field is set up in and around the stator windings. ✓
The rotating magnetic field in the stator sweeps over the rotor conductors (which is in the form of a squirrel cage in the rotor) thus inducing an EMF in the rotor ✓ and a resulting circulating current flowing in the squirrel cage. ✓
Faraday's law.
The magnetic field induced in the rotor is repelled ✓ by the rotating magnetic field induced by the stator ✓ as the nature of the induced current is such that the magnetic field around it opposes the magnetic field induced by the flow of current in the field coils. Lenz's law.
The two magnetic fields interact, causing a force to be exerted between them.
This results in a torque on the rotor shaft which causes the rotor to turn✓ (7)

10.4 Given:

$$Motor \quad \Delta$$
$$V_L = V_{Ph}$$
$$I_L = I_{Ph}$$
$$P_o = 4\,kW$$
$$V_L = 380\,V$$
$$Pf = 0{,}8$$

10.4.1 $P_o = \sqrt{3} V_L I_L \cos\theta$ ✓

$I_L = \dfrac{P_o}{\sqrt{3} V_L \cos\theta}$ ✓

$= \dfrac{4\,000}{\sqrt{3} x 380 x 0,8}$ ✓

$= 7,6\ A$ ✓ (4)

10.4.2 $I_{Ph} = \dfrac{I_L}{\sqrt{3}}$ ✓

$= \dfrac{7,6}{\sqrt{3}}$ ✓

$= 4,39\ A$ ✓ (3)

10.4.3 $Q = \sqrt{3} V_L I_L \sin\theta$ ✓

$but\_\theta = \cos^{-1} 0,8$

$= 36,86^\circ$ ✓

$thus \therefore Q = \sqrt{3} x 380 x 7,6 x \sin 36,86^\circ$ ✓

$= 3K\ \text{var}$ ✓ (4)

10.5 1 – Overload contacts ✓
2 – Normally closed stop ✓
3 – Normally open start ✓
4 – Normally open hold-in ✓ (4)

[30]

TOTAL: 200

FORMULA SHEET

RLC

$$X_L = 2\pi FL$$

$$X_C = \frac{1}{2\pi FC}$$

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

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

$$V_T = \sqrt{V_R^2 + \left(V_C - V_L\right)^2}$$

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

$$Q = \frac{1}{R}\sqrt{\frac{L}{C}}$$

$$Q = \frac{X_L}{R} = \frac{V_L}{V_R}$$

$$Cos\theta = \frac{I_R}{I_T}$$

$$Cos\theta = \frac{R}{Z}$$

Amplifiers

$$Av = \frac{R_f}{R_{in}} + 1$$

$$\beta = \frac{I_c}{I_b}$$

$$I_b = I_e - I_c$$

$$P_G = 10\log\frac{P_0}{P_i}$$

Alternating Current, Transformers and Motors

Single Φ

$$P = VI\cos\theta$$

$$S = VI$$

$$Q = VI\sin\theta$$

Three Φ

$$P = \sqrt{3}\,V_L I_L\cos\theta$$

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

$$Q = \sqrt{3}\,V_L I_L\sin\theta$$

$I_L = \sqrt{3} I_{PH}$ for Δ

$V_L = V_{Ph}$ for Δ

$V_L = \sqrt{3}\,V_{Ph}$ for Y

$I_L = I_{Ph}$ for Y

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

$$\frac{V_1}{V_2} = \frac{N_1}{N_2} = \frac{I_2}{I_1}$$

$$\eta = \frac{P_O}{P_I}$$