Province of the
EASTERN CAPE
EDUCATION

NATIONAL SENIOR CERTIFICATE

GRADE 12

SEPTEMBER 2014

ELECTRICAL TECHNOLOGY

MARKS: **200**

TIME: **3 hours**

ELCTDM

This question paper consists of 9 pages, including a formula sheet.

INSTRUCTIONS AND INFORMATION

1. Answer ALL the questions.
2. Sketches and diagrams must be large, neat and fully labelled.
3. ALL calculations must be shown, and correct to two decimal places.
4. Answers must be clearly numbered.
5. A formula sheet is provided at the end of the paper.
6. Non-programmable calculators may be used.

QUESTION 1: OCCUPATIONAL HEALTH AND SAFETY

1.1 According to the Occupational Health and Safety Act, how is an accident described? (3)

1.2 An employer suspects that a certain employee is using prohibited substances in the workplace. Has the employer the right to place CCTV cameras in the toilets? Justify your answer. (2)

1.3 A fellow learner in the workshop has cut him/herself with a carpet knife. Describe, in detail, what should be done by a first aider to control the bleeding. (5)

[10]

QUESTION 2: THREE-PHASE AC GENERATION

2.1 Name TWO methods of ac power generation used in South Africa that are environmentally friendly. (2)

2.2 No electrical machine is 100% efficient. There are mechanical and electrical losses. List THREE basic losses. (3)

2.3 The advantages of three-phase over single phase are divided into three categories, namely the generation process, the transmission and distribution process, and the load. Select and explain ONE advantage from EACH category. (6)

2.4 An ac star-connected alternator generates 15 kVA at a power factor of 0,87 lagging. The phase voltage is 240 V.

Calculate:

2.4.1 The line voltage (3)

2.4.2 The line current (3)

2.4.3 The active power (3)

[20]

QUESTION 3: THREE-PHASE TRANSFORMERS

3.1 Three-phase transformers are actually three separate single-phase transformers which are connected in a certain way. Once they have been connected and put inside a special container, the unit is called a three-phase transformer. It is of vital importance that the three transformers used are identically matched in all regards. State THREE characteristics that the three transformers must have. (3)

3.2 A 300 kW delta-connected load with a power factor of 0,87 is connected to a delta/star transformer. The primary and secondary line voltages of the transformer are 6 kV and 400 V respectively. Assume that the transformer is 100% efficient.

Calculate:

3.2.1 The line current of the load (3)

3.2.2 The phase-current of the load (3)

3.2.3 The apparent power (3)

3.2.4 The primary line current of the transformer (3)

3.2.5 The primary phase-current of the transformer. (3)

3.3 Name TWO cooling methods used to cool transformers (2)

[20]

QUESTION 4: THREE-PHASE MOTORS AND STARTERS

4.1 Name the THREE main parts of a three-phase induction motor. (3)

4.2 Explain the operation of the 'squirrel cage' induction motor. (6)

4.3 How is the direction of rotation changed in a three-phase induction motor? (1)

4.4 What is the purpose of the Zero-Volt Coil (NVC)? (2)

4.5 What is the purpose of the holding in contacts in a motor stater? (Retaining circuit) (4)

4.6 Mention TWO electrical inspections that must be carried out on a three-phase induction motor after it is installed, and after it is installed , and before it is put into operation. (2)

4.7 A 90 kW three-phase electrical motor has 12 poles in total and has a rated lagging power factor of 0,85. It is connected to a 400 V/50 Hz supply.

Calculate:

4.7.1 The apparent power (3)

4.7.2 The line current (3)

4.7.3 The phase angle (3)

4.7.4 The synchronous speed of the motor (4)

4.7.5 The slip if the shaft speed of the rotor is 1 400 RPM (3)

4.8 Draw a fully labelled wiring diagram of the control circuit of a DOL starter. (6)

[40]

QUESTION 5: RCL CIRCUITS

5.1 How does an increase in frequency affect the following?

5.1.1 Inductive reactance (1)

5.1.2 Capacitive reactance (1)

5.2 Mention TWO characteristics of a series RCL circuit at resonance. (2)

5.3 A parallel RCL circuit consists of a 50 Ω resistor, an inductor having an inductive reactance of 31,42 Ω, and a capacitor of unknown capacitance. The parallel circuit is connected to a 100 V/50 Hz supply. The parallel circuit draws 4,6 A from the supply.

Calculate:

5.3.1 The current through the resistor (3)

5.3.2 The current through the inductor (3)

5.3.3 The current through the capacitor (4)

5.3.4 The value of the unknown capacitor in farads. (6)
[20]

QUESTION 6: LOGIC

6.1 Name the main components of a simple PLC. (4)

6.2 Draw THREE ladder logic symbols used in ladder logic programming and state what each symbol represents. (6)

6.3 Give TWO main advantages of using the PLC over hard-wired logic relays. (2)

6.4 Draw a labelled block diagram of a PLC scan cycle and explain the THREE basic steps in that scan cycle. (8)

6.5 Scenario

A fruit-packing plant has a conveyer belt with three position sensing devices. Each sensing device produces an output of '1' when a box of fruit is sensed in that position. The boxes of fruit must be loaded onto another conveyer belt only when two or more of the sensing devices are producing signals of '1'.

What you must do:

You are required to design a logic system that will perform the given task mentioned in the scenario. Write a ladder logic program that will perform this function. Your design MUST include the following:

6.5.1 Truth table (4)

6.5.2 Boolean expression (2)

6.5.3 Karnaugh map (6)

6.5.4 Gate network (4)

6.5.5 Ladder diagram (4)

[40]

QUESTION 7: AMPLIFIERS

7.1 State THREE characteristics of an ideal operational amplifier. (3)

7.2 With reference to operational amplifiers:

7.2.1 Explain the term '*open loop gain'* (2)

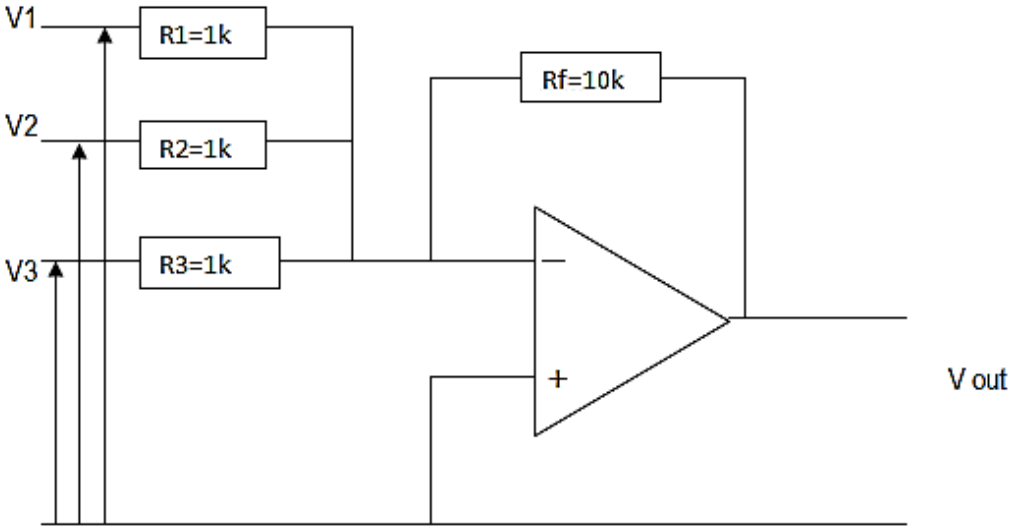
7.2.2 Explain what is meant by *common mode rejection* (3)

7.3 Draw a neat, fully labelled circuit diagram of a differential amplifier. (7)

7.4 Briefly explain the term *negative feedback*. (2)

7.5 State THREE advantages of negative feedback. (3)

7.6

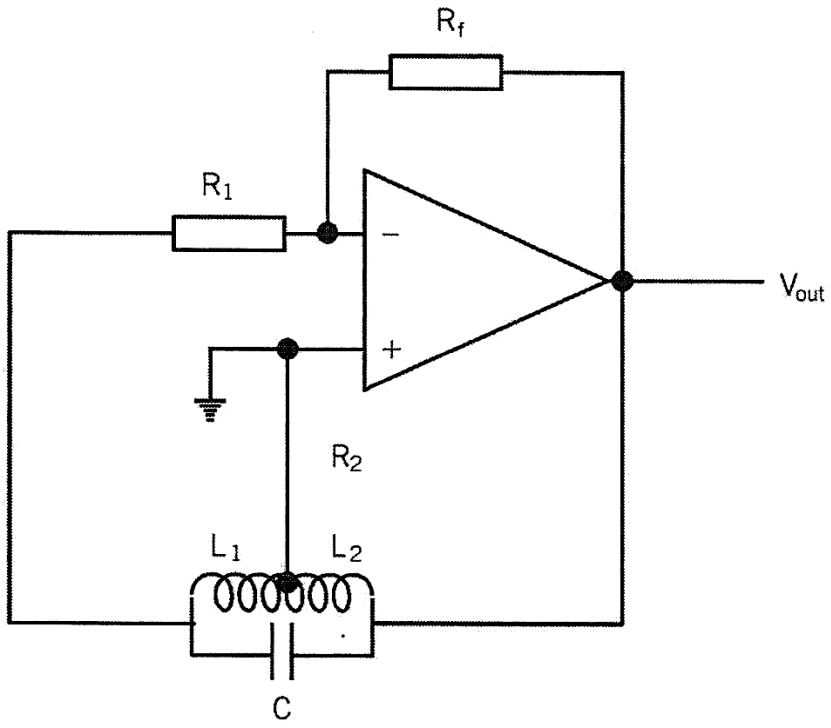


7.6.1 Identify the above circuit. (1)

7.6.2 Give ONE application of the above circuit. (1)

7.6.3 If V1 has an amplitude of 0,2 volts, V2 0,3 volts, and V3 0,5 volts, all at the same frequency, calculate the output voltage and draw the output signal. (5)

7.7 7.7.1 Identify the circuit shown below:



(1)

7.7.2 If the two coils in the circuit shown in QUESTION 7.7.1 each have an inductance of 10 mH and the capacitor has a capacitance of 220 nF, calculate the resonant frequency of the circuit. (3)

7.8	7.8.1	Draw a fully labelled circuit diagram of an op-amp differentiator.	(5)
	7.8.2	Give ONE application of an op-amp differentiator.	(2)
	7.8.3	Draw the input and output waveforms for the op-amp differentiator.	(2)
7.9	7.9.1	Draw a neat, fully labelled circuit diagram of an op-amp Schmitt trigger.	(5)
	7.9.2	State THREE characteristics of a Schmitt trigger.	(3)
	7.9.3	Name TWO electronic test instruments that make use of Schmitt triggers.	(2)
			[50]

TOTAL: 200

ELECTRICAL TECHNOLOGY/ELEKTRIESE TEGNOLOGIE

FORMULA SHEET/FORMULEBLAD

$X_L = 2\pi FL$

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

$P = VI\cos\theta$

$S = VI$

$Q = VI\sin\theta$

Single phase/Enkel-fase

$Z = \sqrt{\mathrm{R}^2 + (\mathrm{X}_L \cong X_C)^2}$

$Z = \sqrt{(R^2 + (X_L \cong I_C)^2}$

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

$V_T = \sqrt{V_R^2 + (V_C \cong V_L)^2}$

$P = \sqrt{3}V_L I_L Cos\theta$

$P = 3V_{ph} I_{ph} Cos\theta$

$S = \sqrt{3}V_L I_L$

$Q = \sqrt{3}V_L I_L Sin\theta$

Three-phase/Drie-fase

$V_R = IR$

$V_L = IX_L$

$V_L = V_{ph}$

$I_L = \sqrt{3}I_{ph}$

Delta

$V_C = IX_C$

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

$V_L = \sqrt{3}V_{ph}$

$V_{ph} = \frac{V_L}{\sqrt{3}}$

Star/Ster

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

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

$\theta = cos^{-1}\frac{I_R}{I_T}$

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

$tan\theta = \frac{X_C}{R}$

$\theta = tan^{-1}\frac{X_C}{R}$

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

$\frac{V_{ph(P)}}{V_{ph(S)}} = \frac{N_P}{N_S} = \frac{I_{ph(P)}}{I_{ph(S)}}$

V_{OUT} = RF $(\frac{V_1}{R_1} + \frac{V_2}{R_2} + \frac{V_3}{R_3})$

END/EINDE

ELECTRICAL TECHNOLOGY/ELEKTRIESE TEGNOLOGIE

FORMULA SHEET/FORMULEBLAD

$X_L = 2\pi FL$

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

$P = VI\cos\theta$

$S = VI$

$Q = VI\sin\theta$

Single phase/Enkel-fase

$Z = \sqrt{\mathrm{R}^2 + (\mathrm{X}_L \cong X_C)^2}$

$Z = \sqrt{(R^2 + (X_L \cong I_C)^2}$

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

$V_T = \sqrt{V_R^2 + (V_C \cong V_L)^2}$

$P = \sqrt{3}V_L I_L Cos\theta$

$P = 3V_{ph} I_{ph} Cos\theta$

$S = \sqrt{3}V_L I_L$

$Q = \sqrt{3}V_L I_L Sin\theta$

Three-phase/Drie-fase

$V_R = IR$

$V_L = IX_L$

$V_L = V_{ph}$

$I_L = \sqrt{3}I_{ph}$

Delta

$V_C = IX_C$

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

$V_L = \sqrt{3}V_{ph}$

$V_{ph} = \frac{V_L}{\sqrt{3}}$

Star/Ster

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

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

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

$\frac{V_{ph(P)}}{V_{ph(S)}} = \frac{N_P}{N_S} = \frac{I_{ph(P)}}{I_{ph(S)}}$

$\theta = cos^{-1}\frac{I_R}{I_T}$

V_{OUT} = RF $(\frac{V_1}{R_1} + \frac{V_2}{R_2} + \frac{V_3}{R_3})$

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

$tan\theta = \frac{X_C}{R}$

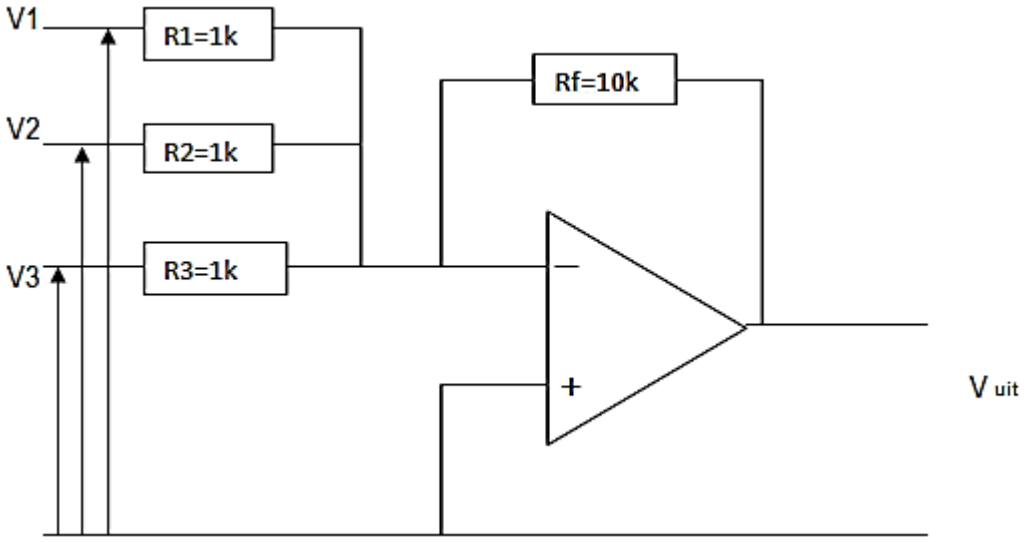
$\theta = tan^{-1}\frac{X_C}{R}$

END/EINDE

7.8	7.8.1	Teken 'n volledige benoemde kringdiagram van 'n operasionele versterker-differensieerder.	(5)
	7.8.2	Noem EEN gebruik van 'n operasionele versterker-differensieerder.	(2)
	7.8.3	Teken die insetgolf en uitsetgolf van die differensieerder.	(2)
7.9	7.9.1	Teken 'n netjiese volledige benoemde kringdiagram van 'n Schmitt-sneller.	(5)
	7.9.2	Noem DRIE eienskappe van 'n Schmitt-sneller.	(3)
	7.9.3	Noem TWEE elektroniese toetsinstrumente wat van Schmitt-snellers gebruik maak.	(2)
			[50]

TOTAAL: 200

7.6

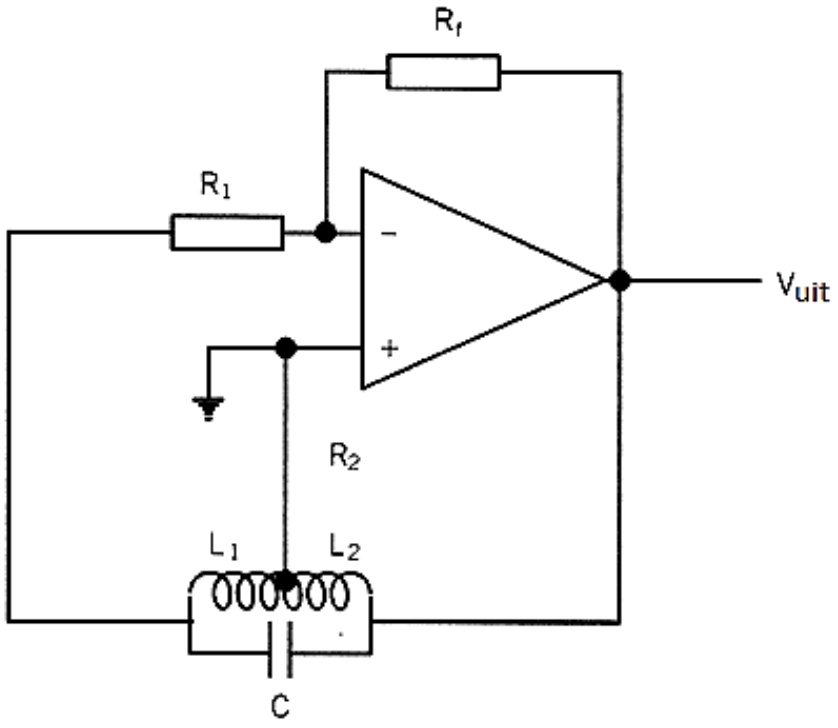


7.6.1 Identifiseer die kring wat hierbo vertoon word. (1)

7.6.2 Noem EEN gebruik van die bostaande kring. (1)

7.6.3 As V1 'n amplitude van 0,2 volts het, V2 0,3 volts, en V3 0,5 volts, almal teen dieselfde frekwensie, bereken die amplitude van die uitsetgolf. Teken die uitsetsein. (5)

7.7 7.7.1 Identifiseer die stroombaan wat onder vertoon is:



(1)

7.7.2 Met verwysing na die stroombaan in VRAAG 7.7.1, bereken die resonante frekwensie as die twee spoele elk 'n induktansie van 10 mH het en die kapasitansie van die kapasitor 220 nF is. (3)

6.5 Scenario

'n Vrugteverpakkingsaanleg het 'n voerband met drieposisie-sensor toestelle. Elke sensor bring 'n afvoer van "1" voort wanneer 'n boks vrugte in daardie posisie aangevoel word. Die bokse vrugte moet op 'n ander voerband gelaai word slegs wanneer twee of meer van die aanvoelingstoestelle seine van "1" voortbring.

Wat jy moet doen:

Daar word van jou vereis om 'n logikastelsel te ontwerp wat bovermelde taak sal uitvoer. Skryf 'n leerlogiese program wat hierdie funksie kan uitvoer. Jou ontwerp MOET die volgende insluit:

6.5.1 Waarheidstabel (4)

6.5.2 Boole-uitdrukking (2)

6.5.3 Karnaugh-kaart (6)

6.5.4 Die heknetwerk (4)

6.5.5 Leerdiagram (4)
[40]

VRAAG 7: VERSTERKERS

7.1 Skryf DRIE eienskappe van 'n ideale operasionele versterker neer. (3)

7.2 Met verwysing na operasionele versterkers:

7.2.1 Verduidelik kortliks die term '*oneindige oop lus wins'* (2)

7.2.2 Verduidelik wat bedoel word met '*oneindige gemeenskaplike modusverwerpingsverhouding*' (3)

7.3 Teken 'n netjiese volledige benoemde kringdiagram van 'n differensiële versterker. (7)

7.4 Verduidelik kortliks die uitdrukking "*negatiewe terugkoppeling*". (2)

7.5 Noem DRIE voordele van negatiewe terugkoppeling. (3)

VRAAG 5: RCL-STROOMBANE

5.1 Hoe word die volgende met ŉ styging in frekwensie beïnvloed?

5.1.1 Induktiewe reaktansie (1)

5.1.2 Kapasitiewe reaktansie (1)

5.2 Noem TWEE eienskappe van ŉ serie RCL-stroombaan by resonansie. (2)

5.3 ŉ Parallel RCL-kring bestaan uit ŉ 50 Ω weerstand, ŉ induktor met ŉ induktiewe reaktansie van 31,42 Ω, en ŉ kapasitor van onbekende kapasitansie. Die parallele-kring word aan ŉ 100 V/50-Hz toevoer verbind. Die parallele kring trek 4,6 A van die toevoer.

Bereken:

5.3.1 Die stroom deur die weerstand (3)

5.3.2 Die stroom deur die induktor (3)

5.3.3 Die stroom deur die kapasitor (4)

5.3.4 Die waarde (in farads) van die onbekende kapasitor (6)
[20]

VRAAG 6: LOGIKA

6.1 Noem die hoofkomponente van ŉ eenvoudige PLB. (4)

6.2 Teken DRIE leerlogika-simbole wat in leerlogika-programmering gebruik word en dui aan wat elke simbool verteenwoordig. (6)

6.3 Noem TWEE hoofvoordele vir die gebruik van die PLB in vergelyking met hardbedrade logiese relês. (2)

6.4 Teken ŉ volledige benoemde blokdiagram van die PLB-skanderingsiklus en verduidelik die DRIE basiese stappe van die skanderingsiklus. (8)

3.2 'n 300 kW deltaverbinde las met 'n arbeidsfaktor van 0,87 word aan 'n delta-ster transformator verbind. Die primêre en sekondêre lynspannings is 6 kV en 400 V onderskeidelik. Gestel die rendement van die transformator is 100%.

Bereken:

3.2.1 Die lynstroom van die las (3)

3.2.2 Die fasestroom van die las (3)

3.2.3 Die skyndrywing (3)

3.2.4 Die primêre lynstroom van die transformator (3)

3.2.5 Die primêre fasestroom van die transformator (3)

3.3 Noem TWEE metodes wat gebruik word om transformators te verkoel. (3)
[20]

VRAAG 4: DRIE-FASE MOTORE EN AANSITTERS

4.1 Noem die DRIE hoofdele van 'n drie-fase induksiemotor. (3)

4.2 Verduidelik die werking van 'n drie-fase kourotormotor. (6)

4.3 Hoe word die rigting van rotasie in 'n drie-fase induksiemotor verander? (1)

4.4 Wat is die doel van die nul-spanning spoel (NSS) met verwysing na 'n motoraansitter? (2)

4.5 Wat is die doel van die inhoukontakte of grendelkontak in 'n motor-aansitter? (4)

4.6 Noem TWEE elektriese inspeksies wat uitgevoer moet word op 'n drie-fase induksiemotor nadat dit geïnstalleer is, en voordat dit aangesit word. (2)

4.7 'n 90 kW drie-fase elektriese motor het altesame 12 pole, en het 'n nalopende arbeidsfaktor van 0,85. Dit word aan 'n 400 V/50 Hz-toevoer verbind.

Bereken:

4.7.1 Die skyndrywing (3)

4.7.2 Die lynstroom (3)

4.7.3 Die fasehoek (3)

4.7.4 Die sinkrone spoed van die motor (4)

4.7.5 Die glip indien die asspoed van die motor 1 400 OPM is (3)

4.8 Teken 'n volledige benoemde kontrolediagram van 'n DOL-aansitter. (6)
[40]

VRAAG 1: BEROEPSGESONDHEID EN -VEILIGHEID

1.1 Wat is 'n ongeluk volgens die Wet op Beroepsgesondheid en -Veiligheid? (3)

1.2 'n Werkgewer vermoed dat 'n sekere werker verbode dwelmmiddels in die werksplek misbruik. Het die werkgewer die reg om CCTV-kameras in die toilette te plaas? Regverdig jou antwoord. (2)

1.3 'n Medestudent in die werkswinkel het hom/haar met 'n tapytmes gesny. Beskryf, in detail, wat 'n noodhulp-lid moet doen om die bloeding te beheer. (5)

[10]

VRAAG 2: DRIE-FASE WS-OPWEKKING

2.1 Noem TWEE omgewingsvriendelike kragopwekkingsmetodes wat in Suid-Afrika gebruik word. (2)

2.2 Geen elektriese masjien is 100% doeltreffend nie. Daar bestaan elektriese en meganiese verliese. Noem DRIE basiese verliese. (3)

2.3 Die voordele van drie-fase in vergelyking met enkelfase word in drie kategorieë opgedeel, naamlik die opwekkingsproses, die transmissie-en-verspreidingsproses, en die las. Selekteer en verduidelik EEN voordeel van ELKE kategorie. (6)

2.4 'n WS-sterverbinde alternator wek 15 kVA op teen 'n arbeidsfaktor van 0,87 nalopend. Die fasespanning is 240 V.

Bereken:

2.4.1 Die lynspanning (3)

2.4.2 Die lynstroom (3)

2.4.3 Die aktiewe drywing (3)

[20]

VRAAG 3: DRIE-FASE TRANSFORMATORS

3.1 Drie-fase transformators is eintlik drie afsonderlike enkelfase transformators wat op 'n sekere manier aanmekaar verbind is. Sodra hulle verbind is, en in 'n spesiale houer geplaas word, word dit 'n drie-fase transformator genoem. Dit is van wesenlike belang dat die drie transformators wat gebruik word om 'n drie-fasetransformator te vorm, in alle opsigte identiese eienskappe moet hê. Gee DRIE eienskappe van die drie transformators. (3)

INSTRUKSIES EN INLIGTING

1. Beantwoord AL die vrae.
2. Sketse en diagramme moet groot en netjies wees, met volle byskrifte.
3. ALLE berekeninge moet korrek tot twee desimale plekke getoon word.
4. Antwoorde moet duidelik genommer wees.
5. ’n Formuleblad is aan die einde van hierdie vraestel aangeheg.
6. Nieprogrammeerbare sakrekenaars mag gebruik word.

Province of the
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EDUCATION

NASIONALE SENIOR SERTIFIKAAT

GRAAD 12

SEPTEMBER 2014

ELEKTRIESE TEGNOLOGIE

PUNTE: **200**

TYD: **3 uur**

ELCTDM

Hierdie vraestel bestaan uit 9 bladsye, insluitend 'n formuleblad.