Province of the
EASTERN CAPE
EDUCATION

**DIRECTORATE SENIOR CURRICULUM MANAGEMENT (SEN-FET)**

**HOME SCHOOLING SELF-STUDY WORKSHEET**

<table>
<tr><td>SUBJECT</td><td>POWER SYSTEMS</td><td>GRADE</td><td>12</td><td>DATE</td><td>APRIL 2020</td></tr>
<tr><td>TOPIC</td><td>THREE PHASE TRANSFORMERS</td><td>TERM 1 REVISION</td><td>()</td><td>TERM 2 CONTENT</td><td>(√ )</td></tr>
<tr><td>TIME ALLOCATION</td><td>2 hrs.</td><td colspan="4" rowspan="2"><u>TIPS TO KEEP HEALTHY</u><br><br>1. WASH YOUR HANDS thoroughly with soap and water for at least 20 seconds. Alternatively, use hand sanitizer with an alcohol content of at least 60%.<br>2. PRACTICE SOCIAL DISTANCING – keep a distance of 1m away from other people.<br>3. PRACTISE GOOD RESPIRATORY HYGIENE: cough or sneeze into your elbow or tissue and dispose of the tissue immediately after use.<br>4. TRY NOT TO TOUCH YOUR FACE. The virus can be transferred from your hands to your nose, mouth and eyes. It can then enter your body and make you sick.<br>5. STAY AT HOME.</td></tr>
<tr><td>INSTRUCTIONS</td><td>The only way of mastering calculations is by working through examples (practice, practice, practice)</td></tr>
</table>

**EXAMINATION TIPS**

Most calculations only count three marks, 1 mark for selecting the correct formula (no marks for the manipulation of the formula), 1 mark for correctly substituting the values in formula and 1 mark for the correct answer and unit. (NO unit

with answer NO mark for answer)

➢ Where possible always make a neat labelled drawing of the circuit.

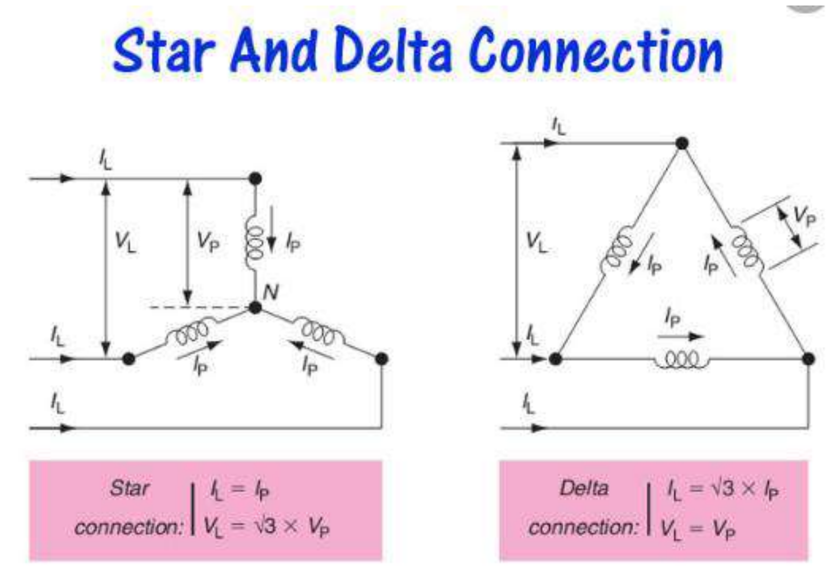
➢ Write down all the given information before you start your calculation.

➢ When doing calculations relating to transformer equations

($\frac{V(ph)(p)}{V(ph)(s)} = \frac{Np}{Ns} = \frac{I(ph)(s)}{I(ph)(p)}$) always use phase values (voltages and currents)

➢ Practice, Practice and more Practice.

The following formulas are important and even when given you need to know when and where to use it.
**Star connection**
VL =√3. VP and IL = IP




***Power:***

*Apparent power (S)* $P_{app} = \sqrt{3}.V_L.I_L$

*Reactive power(Q)* $P_R = \sqrt{3}.V_L.I_L \sin \Theta$

*True power* $P = \sqrt{3}.VL.IL \cos \Theta$ *or* $P = S \cos$

Transformer equation:

$$\frac{V(ph)(p)}{V(ph)(s)} = \frac{Np}{Ns} = \frac{I(ph)(s)}{I(ph)(p)}$$ (Only use phase values)

NB:

➢ The primary and secondary voltages are directly proportional to the number of turns on each coil

➢ Primary and secondary currents are inversely proportional to the number of turns in each coil.

➢ The primary and secondary voltages are inversely proportional to the currents.

*NB* The only way of mastering calculations is by working through examples (practice, practice, practice)

What do you understand by directly proportional and inversely proportional quantities?

**Directly proportional**: when the one quantity increases the other one also increases or when it decreases the other quantity also decreases.

**Inversely proportional**: When the one quantity increases the other quantity decreases and when the one decreases, the other quantity increases.

(To take a very simple example to demonstrate the concepts **Directly proportional** and **Inversely proportional** is:

$I = \frac{V}{R}$, which is Ohm's law, relating $V$ the voltage (potential difference), $I$ the current and $R$ the resistance of the conductor.

Ohm's law is fundamental in the study of electricity. If $R$ is a constant, $I$ is directly proportional to $V$. If $V$ is a constant, $I$ is inversely proportional to $R$.)

**EXAM QUESTION EXAMPLE**

4.5 A 12 kVA three-phase transformer is connected in delta-star and has a turns ratio of 5 : 1. The primary line voltage is 2,2 kV.

Given:

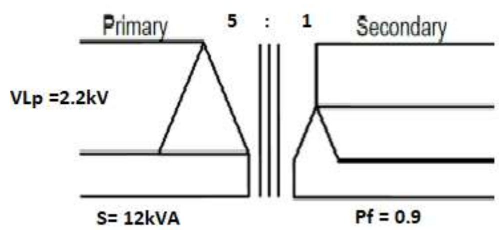
S = 12 kVA
TR = 5 : 1
$V_L$ = 2,3 kV
pf = 0,9 lagging

Calculate the:

| | | |
|---|---|---|
| 4.5.1 | Primary phase voltage | (2) |
| 4.5.2 | Secondary line voltage | (6) |
| 4.5.3 | Active power if the transformer has a lagging power factor of 0,9 | (3) |

**Model answer to question:**

Do the drawing with all given information?




4.5 4.5.1 Primary phase voltage

$V_{PH} = V_L$ ✓

$= 2,2\,kV$ ✓ (Delta configuration VL = VPH)

| | |
|---|---|
| | 4.5.2 Secondary line voltage<br>$\frac{V_{ph(s)}}{V_{ph(p)}} = \frac{N_s}{N_p}$ ✓<br>$V_{ph(s)} = \frac{1}{5} \times 2200$ ✓<br>$= 440\,V$ ✓<br>$V_L = \sqrt{3} V_{PH}$ ✓<br>$= \sqrt{3} \times 440$ ✓<br>$= 762{,}08\,V$ ✓<br>(Phase voltage (secondary) must first be calculated before secondary line voltage can be calculated i.e. the two calculations needed)<br>4.5.3 Active power<br>$P = S \times \cos\theta$ ✓<br>$= 12000 \times 0{,}9$ ✓<br>$= 10{,}800\,W$ ✓<br>(Carefully look at what information is given before deciding on the formula to use)<br>**NB!!** IL(s) was not (given) available so the formula *P = √3.VL.IL cos Θ could not be used* |

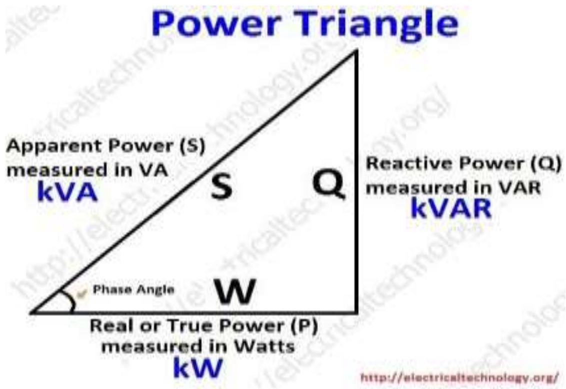
**Power factor:**

The **power factor** of an AC circuit is defined as the **ratio** of the real **power** (W) consumed by a circuit to the **apparent power** (VA) consumed by the same circuit. This therefore gives us: **Power Factor** = Real **Power**/**Apparent Power**, or **p.f.** = W/VA

PF = pf = cos Θ.

We always strive to get the power factor in a circuit as close as possible to '1', if its less than '1' more power is being used and your cost for your electricity will be more.

- **A common mistake often made is when the power factor Cos Θ is given (e.g. Cos Θ = 0.9) and must only be substituted in the formula, learners still want to calculate Cos (0.9) then substitute this new value. This is totally wrong, because you must simply just substitute Cos Θ with the given value in the formula.**




The magneto motive force (mmf) = I x N for both primary and secondary side

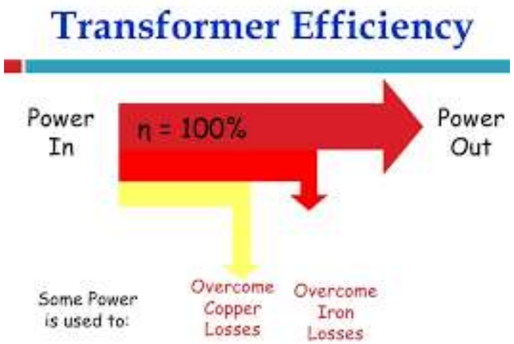
An increase in the load will lead to an increase in the (mmf) on the secondary side. The mmf on the primary will increase by the same amount. As the supply voltage is fix, only the primary current can increase.

**Calculation of efficiency with no losses (Ideal transformer)**

Efficiency (ŋ) = $\frac{Output\ power\ (W)}{Input\ power\ (VA)}$ X 100%

Calculation of efficiency with losses (Copper + Core /Iron losses) Ideal Transformers is said to have no losses i.e. 100% efficient. In reality the efficiency of transformers is in the vicinity of 90% -97% this mainly because of the different losses in the transformer.

Efficiency (ŋ) = $\frac{Output\ power\ (W)}{Input\ power\ (VA)=Output\ power+copper\ losses+core\ losses}$ X 100%




**NB:** Please first do the questions on your own before consulting any resources

Time per question (1 mark = 1 minute)

Refer to chapter activities(on Transformers) and do all the questions related to this section of the work.

Refer to the latest THREE Matric question papers and do the questions relating to the work covered in this of lesson.