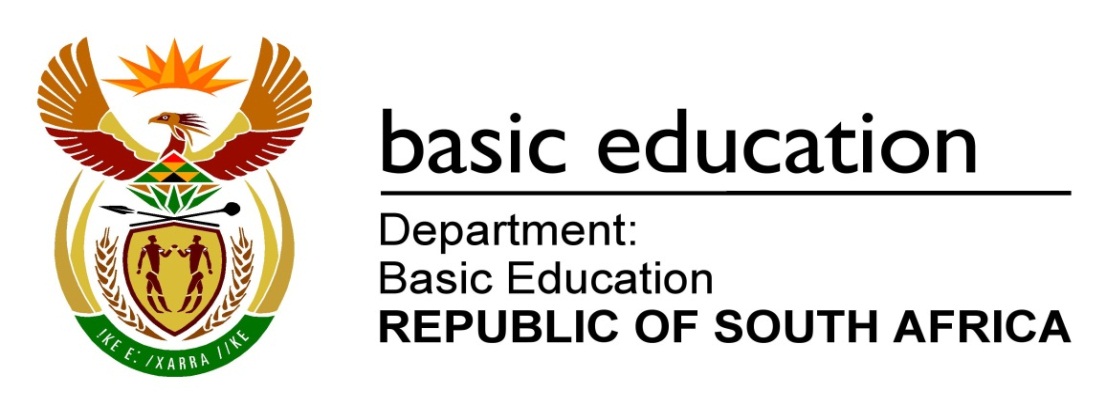
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# NATIONAL

# SENIOR CERTIFICATE

# GRADE 12

# ELECTRICAL TECHNOLOGY: POWER SYSTEMS

# EXEMPLAR 2018

**MARKS: 200**

**TIME: 3 hours**

**This question paper consists of 11** **pages and a 2-page formula sheet.**

|  |  |  |
| --- | --- | --- |
| **INSTRUCTIONS AND INFORMATION** |  |  |

|  |  |  |  |
| --- | --- | --- | --- |
| 1.  2. | This question paper consists of SIX questions.  Answer ALL the questions. |  |  |
|  |  |  |  |
| 3. | Sketches and diagrams must be large, neat and fully labelled. |  |  |
|  |  |  |  |
| 4. | Show ALL calculations and round off answers correctly to TWO decimal places. |  |  |
|  |  |  |  |
| 5. | Number the answers correctly according to the numbering system used in this question paper. |  |  |
|  |  |  |  |
| 6. | You may use a non-programmable calculator. |  |  |
|  |  |  |  |
| 7. | Show the units for ALL answers of calculations. |  |  |
|  |  |  |  |
| 8. | A formula sheet is provided at the end of this question paper. |  |  |
|  |  |  |  |
| 9. | Write neatly and legibly. |  |  |

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| --- | --- | --- | --- |
| **QUESTION 1: OCCUPATIONAL HEALTH AND SAFETY (GENERIC)** | |  |  |
|  |  |  |  |
| 1.1 | Define the term *workplace* with reference to the Occupational Health and Safety Act, 1993 (Act 85 of 1993) |  | (2) |
|  |  |  |  |
| 1.2 | Name TWO general duties for employees at the workplace. |  | (2) |
|  |  |  |  |
| 1.3 | Explain why 'insufficient ventilation' is an unsafe condition in the workshop. |  | (2) |
|  |  |  |  |
| 1.4 | State TWO functions of a health and safety representative. |  | (2) |
|  |  |  |  |
| 1.5 | Explain *quantitative risk analysis*. |  | (2) |
|  |  |  | **[10]** |

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| **QUESTION 2: RLC CIRCUITS (GENERIC)** | | |  |  |
|  |  | |  |  |
| 2.1 | Explain the phase relationship between current and voltage in the following AC circuits: | |  |  |
|  |  | |  |  |
|  | 2.1.1 | Resistive circuit |  | (2) |
|  |  |  |  |  |
|  | 2.1.2 | Pure capacitive circuit |  | (2) |
|  |  |  |  |  |
|  | 2.1.3 | Pure inductive circuit |  | (2) |

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| 2.2 | FIGURE 2.2 below shows an RLC series circuit, which consists of a  12 Ω resistor, a 30 mH inductor and a 150 µF capacitor, all connected across a 120 V/60 Hz supply. | | |  |  |
|  |  | | |  |  |
|  |  | | |  |  |
|  | **FIGURE 2.2: RLC SERIES CIRCUIT** | | |  |  |
|  |  | | |  |  |
|  | Given: | | |  |  |
|  |  | | |  |  |
|  | R | = | 12 Ω |  |  |
|  | L | = | 30 mH |  |  |
|  | C | = | 150 µF |  |  |
|  | V**s** | = | 120 V/60 Hz |  |  |
|  | f | = | 50 Hz |  |  |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Calculate the: | |  |  |
|  |  |  |  |  |
|  | 2.2.1 | Inductive reactance |  | (3) |
|  |  |  |  |  |
|  | 2.2.2 | Capacitive reactance |  | (3) |
|  |  |  |  |  |
|  | 2.2.3 | Impedance |  | (3) |
|  |  |  |  |  |
|  | 2.2.4 | Total current |  | (3) |
|  |  |  |  |  |
|  | 2.2.5 | Power factor |  | (3) |
|  |  |  |  |  |
|  | 2.2.6 | State whether the phase angle is leading or lagging. |  | (1) |

|  |  |  |  |  |  |
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| 2.3 | Refer to FIGURE 2.3 and answer the questions that follow. | | |  |  |
|  |  | | |  |  |
|  |  | | |  |  |
|  | **FIGURE 2.3 : FREQUENCY VERSUS IMPEDANCE** | | |  |  |
|  |  | | |  |  |
|  | 2.3.1 | Describe how an increase in the frequency of the supply voltage will affect the: | |  |  |
|  |  |  | |  |  |
|  |  | (a) | Inductive reactance |  | (2) |
|  |  |  |  |  |  |
|  |  | (b) | Capacitive reactance |  | (2) |
|  |  |  | |  |  |
|  | 2.3.2 | Explain why the response of line R is parallel to line F | |  | (2) |
|  |  |  | |  |  |
|  | 2.3.3 | Name the electrical quantity that is equal to R at point D. | |  | (1) |
|  |  |  | |  |  |

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| 2.4 | An RLC parallel circuit consists of a 30 mH inductor, a 10 Ω resistor and a  120 µF capacitor connected across a 120 V alternating supply. | | |  | |  | |
|  |  | | |  | |  | |
|  | Given: | | |  | |  | |
|  |  | | |  | |  | |
|  | L | = | 30 mH | |  | |  | |
|  | C | = | 120 µF | |  | |  | |
|  | R | = | 10 Ω | |  | |  | |
|  | V | = | 120 V | |  | |  | |
|  |  | | |  | |  | |
|  | Calculate the: | | |  | |  | |
|  |  | | |  | |  | |
|  | 2.4.1 | | Resonant frequency |  | | (3) | |
|  |  | |  |  | |  | |
|  | 2.4.2 | | Q-factor |  | | (5) | |
|  |  | |  |  | |  | |
|  | 2.4.3 | | Bandwidth |  | | (3) | |
|  |  | |  |  | | **[40]** | |

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| **QUESTION 3: THREE-PHASE AC GENERATION (SPECIFIC)** | | | | |  |  |
|  | | | | |  |  |
| 3.1 | Name THREE advantages of a three-phase AC generation over a single-phase AC generation. | | | |  | (3) |
|  |  | | | |  |  |
| 3.2 | Draw a fully labelled waveform to represent the generation of a three-phase voltage system. | | | |  | (6) |
|  |  | | | |  |  |
| 3.3 | Explain the following terms: | | | |  |  |
|  |  | | | |  |  |
|  | 3.3.1 | | Efficiency | |  | (2) |
|  |  | |  | |  |  |
|  | 3.3.2 | | Power factor | |  | (2) |
|  |  | | | |  |  |
| 3.4 | Refer to the losses occurring during the transmission of electrical power  from the power station to the distributing point and answer the following questions: | | | |  |  |
|  |  | | | |  |  |
|  | 3.4.1 | | Name the main type of losses occurring in the transmission line. | |  | (1) |
|  |  | |  | |  |  |
|  | 3.4.2 | | Describe how these losses can be reduced. | |  | (2) |
|  |  | | | |  |  |
| 3.5 | A 380 V/50 Hz three-phase AC delta-connected motor has an output power of 12,75 kW and operates at a lagging power factor of 0,77. The efficiency of the motor is 85%. | | | |  |  |
|  |  | | | |  |  |
|  | Given: | | | |  |  |
|  |  | | | |  |  |
|  | VL  ŋ  θ  Pout | =  =  =  = | | 380 V  85%  0,77 lagging  12,75 kW |  |  |
|  |  | | | |  |  |
|  | Calculate the: | | | |  |  |
|  |  | | | |  |  |
|  | 3.5.1 | | Input power | |  | (3) |
|  |  | | | |  |  |
|  | 3.5.2 | | Line current | |  | (3) |
|  |  | | | |  |  |
|  | 3.5.3 | | Phase current | |  | (3) |
|  |  | | | |  |  |
| 3.6 | State the function of a kWh meter. | | | |  | (2) |
|  |  | | | |  |  |
| 3.7 | A two-wattmeter method is used to measure the input power in a balanced three-phase load. If the wattmeter readings are 8 kW and 4 kW respectively, calculate the total input power. | | | |  | (3) |
|  | | | | |  | **[30]** |
|  | | | | |  |  |

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| **QUESTION 4: THREE-PHASE TRANSFORMERS (SPECIFIC)** | |  |  |
|  | |  |  |
| 4.1 | Name TWO construction types of transformers.  + |  | (2) |
|  |  |  |  |

|  |  |  |  |
| --- | --- | --- | --- |
| 4.2 | State THREE factors that may contribute to the excessive heating of transformers. |  | (3) |

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 4.3 | Explain how the following losses occur in the transformers: | | | |  | |  | |
|  |  | | | |  | |  | |
|  | 4.3.1 | | Hysteresis losses | |  | | (3) | |
|  |  | |  | |  | |  | |
|  | 4.3.2 | | Eddy current losses in a transformer | |  | | (3) | |
|  |  | |  | |  | |  | |
| 4.4 | Describe how the phase current is induced in the secondary winding of the transformer. | | | |  | | (4) | |
|  |  | | | |  | |  | |
| 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 | |  | |  | |
|  | VL | = | | 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) | |
|  |  | |  | |  | |  | |
| 4.6 | Refer to QUESTION 4.5 and answer the questions that follow. | | | |  | |  | |
|  |  | |  | |  | |  | |
|  | 4.6.1 | | Name TWO applications of this type of transformer. | |  | | (2) | |
|  |  | |  | |  | |  | |
|  | 4.6.2 | | State, with reason, whether the transformer is a step-down transformer or a step-up transformer. | |  | | (2) | |
|  | | | | |  | | **[30]** | |
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| **QUESTION 5: THREE-PHASE MOTORS AND STARTERS (SPECIFIC)** | | | |  | |  | |
|  | | | |  | |  | |
| 5.1 | Define the term *slip* with reference to a three-phase AC squirrel-cage induction motor. | | |  | | (2) | |
|  |  | | |  | |  | |
| 5.2 | State TWO mechanical inspections that must be conducted after installation and before commissioning. | | |  | | (2) | |
|  |  | | |  | |  | |
| 5.3 | Give TWO reasons why the rotor of the squirrel-cage induction motor is skewed. | | |  | | (2) | |
|  |  | | |  | |  | |
| 5.4 | Explain how the torque is developed in a squirrel-cage induction motor. | | |  | | (3) | |
|  |  | | |  | |  | |
| 5.5 | State TWO applications of a squirrel-cage induction motor. | | |  | | (2) | |
|  |  | | |  | |  | |
| 5.6 | Refer to FIGURE 5.6 below and answer the questions that follow. | | |  | |  | |
|  |  | | |  | |  | |
|  | (a)  (b)  (c) | | | | |  | |
|  | **FIGURE 5.6: CHARACTERISTIC CURVE OF SPEED VS TORQUE** | | | | |  | |
|  |  | | |  | |  | |
|  | 5.6.1 | Identify the torque developed at the following points: | | |  | |  | |
|  |  |  | | |  | |  | |
|  |  | (a) |  | |  | | (1) | |
|  |  |  |  | |  | |  | |
|  |  | (b) |  | |  | | (1) | |
|  |  |  |  | |  | |  | |
|  | 5.6.2 | Explain why the torque developed at (c) is zero | | |  | | (2) | |
|  |  | | |  | |  | |

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 5.7 | FIGURE 5.7 below shows a control circuit. Study the diagram and answer the questions that follow. | | | | |  | | |  | | |
|  |  | | | | |  | | |  | | |
|  |  | | | | | | | |  | | |
|  | **FIGURE 5.7: CONTROL CIRCUIT** | | | | | | | |  | | |
|  |  | | | | |  | | |  | | |
|  | 5.7.1 | Identify the control circuit diagram in FIGURE 5.7. | | | |  | | | | (1) | | |
|  |  |  | | | |  | | | |  | | |
|  | 5.7.2 | Describe what will happen to the motor if the normally closed contact of the overload is permanently closed due to a fault. | | | |  | | | | (2) | | |
|  |  |  | | | |  | | | |  | | |
|  | 5.7.3 | Describe the function of the following components as used in the circuits: | | | |  | | | |  | | |
|  |  |  | | | |  | | | |  | | |
|  |  | (a) | | | Stop button |  | | | | (2) | | |
|  |  |  | | |  |  | | | |  | | |
|  |  | (b) | | | MC1 (N/O1) |  | | | | (2) | | |
|  |  |  | | |  |  | | | |  | | |
|  | 5.7.4 | State why the N/C contact of MC3 is connected in series with a  star contactor. | | | |  | | | | (2) | | |
|  |  |  |  | | | |  | | | |  | | |
| 5.8 | A three-phase 15 kW induction motor is connected in delta to a 380 V/50 Hz supply. The motor has a lagging power factor of 0,9. | | | | |  | | |  | | |
|  |  | | | | |  | | |  | | |
|  | Given: | | | | |  | | |  | | |
|  |  | | | | |  | | |  | | |
|  | P  f  Cos Ø  VL | =  =  =  = | | 15 kW  50 Hz  0,8 lagging  380 V | |  | | |  | | |
|  |  | | | | |  | | |  | | |
|  | Calculate the: | | | | |  | | |  | | |
|  |  | | | | |  | | |  | | |
|  | 5.8.1 | Line current drawn from the supply | | | | | |  | | (3) | | |
|  |  | | | | |  | | |  | | |
|  | 5.8.2 | Apparent power of the motor | | | | | |  | | (3) | | |
|  |  | | | | |  | | | **[30]** | | |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **QUESTION 6: PROGRAMMABLE LOGIC CONTROLLERS (SPECIFIC)** | | |  |  |
|  | | |  |  |
| 6.1 | State THREE safety precautions to be observed when connecting external cables to a PLC. | |  | (3) |
|  |  | |  |  |
| 6.2 | Name TWO types of hardware components of the PLC other than the central processing unit (CPU). | |  | (2) |
|  |  | |  |  |
| 6.3 | State THREE advantages of the PLC over the hardwired system. | |  | (3) |
|  |  | |  |  |
| 6.4 | State why an interface is connected at the inputs of the CPU. | |  | (2) |
|  |  | |  |  |
| 6.5 | Explain the programmed scan cycle under the following headings: | |  |  |
|  |  | |  |  |
|  | 6.5.1 | Input scan |  | (3) | |
|  |  |  |  |  | |
|  | 6.5.2 | Process scan |  | (3) | |
|  |  |  |  |  | |
|  | 6.5.3 | Output scan |  | (2) | |
|  |  |  |  |  | |
| 6.6 | Refer to analogue and digital input as used in the PLC and answer the following questions: | |  |  |
|  |  | |  |  |
|  | 6.6.1 | Explain the difference between an *analogue input* and a *digital input* |  | (4) | |
|  |  |  |  |  | |
|  | 6.6.2 | Give TWO examples of the digital inputs. |  | (2) | |
|  |  |  |  |  | |
|  | 6.6.3 | State THREE applications of the inductive proximity sensor as an analogue input. |  | (3) | |
|  |  | |  |  |
| 6.7 | State when a maker/flag function is used in the PLC. | |  | (2) |
|  |  | |  |  |
| 6.8 | Refer to FIGURE 6.8 on the next page and draw the PLC ladder logic diagram that would execute the same function. | |  |  |

|  |  |  |  |
| --- | --- | --- | --- |
| 6.8 | Refer to FIGURE 6.8 below and draw the PLC ladder logic diagram that would execute the same function. |  |  |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  |  | | | |  |
|  | **FIGURE 6.8: CONTROL CIRCUIT** | | | | (10) |
|  |  | | |  |  |
| 6.9 | State THREE basic applications of the variable speed drive (VSD). | | |  | (3) |
|  |  | | |  |  |
| 6.10 | Name THREE methods in which the speed of the motor can be controlled with the exception of pulse width modulation. | | |  | (3) |
|  |  | | |  |  |
| 6.11 | Describe how the pulse width modulation as a method of varying the speed of the motor achieves its function. | | |  | (4) |
|  |  |  | |  |  |
| 6.12 | Describe how the VSD controls the speed of motors under the following  subcircuits: | | |  |  |
|  |  | | |  |  |
|  | 6.12.1 | | Diode bridge rectifier |  | (2) |
|  |  | |  |  |  |
|  | 6.12.2 | | Filtering circuit |  | (3) |
|  |  | |  |  |  |
|  | 6.12.3 | | Inverting circuit |  | (3) |
|  |  | |  |  |  |
| 6.13 | Describe the concept of *regenerative braking*. | | |  | (3) |
|  |  | | |  | **[60]** |
|  |  | | |  |  |
|  | **TOTAL:** | | |  | **200** |
|  |  | | |  |  |

|  |  |
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| **FORMULA SHEET** | |
| **THREE-PHASE AC GENERATION** | **RLC CIRCUIT** |
|  |  |
| **STAR** | and |
| and |  |
|  |  |
| **DELTA** | **SERIES** |
| and |  |
|  |  |
|  |  |
| **POWER** | and |
|  | and |
|  |  |
|  |  |
|  |  |
| **TWO-WATTMETER METHOD** |  |
|  |  |
| **THREE-PHASE TRANSFORMERS** |  |
| **STAR** | **PARALLEL** |
| and |  |
|  | and |
| **DELTA** |  |
| and |  |
| **POWER** |  |
|  |  |
|  |  |
|  |  |

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|  |  |
|  |
| **MOTOR SPEED** |
|  |
|  |
|  |
| **THREE-PHASE MOTORS AND STARTERS** |
|  |
| **STAR** |  |
| and |  |
|  |  |
| **DELTA** |  |
| and |  |
|  |
| **POWER** |
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