AS91526: Demonstrate understanding of electrical systems
Level 3 Credits 6

This achievement standard involves demonstrating understanding of electrical systems.

Achievement Criteria

Achievement	Achievement with Merit	Achievement with Excellence
• Demonstrate understanding of electrical systems.	• Demonstrate in-depth understanding of electrical systems.	• Demonstrate comprehensive understanding of electrical systems.

Assessment is limited to a selection from the following:

Resistors in DC Circuits
Internal resistance; simple application of Kirchhoff's Laws.

Capacitors in DC Circuits
Parallel plate capacitor; capacitance; dielectrics; series and parallel capacitors; charge/time, voltage/time and current/time graphs for a capacitor; time constant; energy stored in a capacitor.

Inductors in DC Circuits
Magnetic flux; magnetic flux density; Faraday's Law; Lenz's Law; the inductor; voltage/time and current/time graphs for an inductor; time constant; self inductance; energy stored in an inductor; the transformer.

AC Circuits
The comparison of the energy dissipation in a resistor carrying direct current and alternating current; peak and rms voltage and current; voltage and current and their phase relationship in LR and CR series circuits; phasor diagrams; reactance and impedance and their frequency dependence in a series circuit; resonance in LCR circuits.

Relationships:

$E = \frac{1}{2}QV$ $\quad Q = CV$ $\quad C = \frac{\varepsilon_o \varepsilon_r A}{d}$ $\quad C_T = C_1 + C_2 + \ldots$ $\quad \tau = RC$

$\frac{1}{C_T} = \frac{1}{C_1} + \frac{1}{C_2} + \ldots$ $\quad \phi = BA$ $\quad \varepsilon = -L\frac{\Delta I}{\Delta t}$ $\quad \varepsilon = -\frac{\Delta \phi}{\Delta t}$

$\frac{N_p}{N_s} = \frac{V_p}{V_s}$ $\quad E = \frac{1}{2}LI^2$ $\quad \tau = \frac{L}{R}$

$I = I_{MAX}\sin\omega t$ $\quad V = V_{MAX}\sin\omega t$ $\quad I_{MAX} = \sqrt{2}I_{rms}$

$V_{MAX} = \sqrt{2}V_{rms}$ $\quad X_C = \frac{1}{\omega C}$

$X_L = \omega L$ $\quad V = IZ$ $\quad \omega = 2\pi f$

$f_0 = \frac{1}{2\pi\sqrt{LC}}$

Achievement criteria

1. *Demonstrate understanding* involves showing an awareness of how simple facets of phenomena, concepts, or principles relate to a given situation.

   Demonstrate in-depth understanding involves giving explanations for phenomena, concepts, or principles that relate to a given situation.

   Demonstrate comprehensive understanding involves connecting concepts or principles that relate to a given situation.

2. *Electrical systems* include mathematical solutions and/or written descriptions. Written descriptions may include graphs or diagrams.

This achievement standard replaced unit standard 6389, unit standard 6390, and AS90523.
This standard matches – virtually entirely – the content of the old standard AS90523.

Achievement

Make sure you can:

- Identify or describe aspects of phenomena, concepts, or principles
- Solve straightforward problems that involve a single-step process
- Recognise correct concept/phenomenon/principle and give a simple descriptive answer in both written and diagrammatic form, for example:
  - the discharge of a capacitor in a closed circuit
  - that a capacitor takes five time constants to become fully charged or discharged
  - the effect of the resistance on the discharge current from a capacitor
- Recognise the correct concept and apply reasonable mathematical skills, for example:
  - the relationship between angular and cyclic frequency
  - the relationship between inductor reactance and angular frequency

Achievement with Merit

Make sure you can:

- Give accurate explanations in terms of phenomena, concepts, principles, and/or relationships
- Solve problems that may involve using a complex formula or rearrangement or some deduction as to the relevant concept or principle
- Use physics terminology to explain principles related to DC circuits and capacitance, as well as electromagnetic induction and AC circuits

Achievement with Excellence

Make sure you can:

- Give concise and accurate explanations that show clear understanding in terms of phenomena, concepts, principles, and/or relationships. Your answers will typically have minimal irrelevancies. In other words, you cannot include any explanations that are not relevant.
- Solve complex problems that will involve more than one process and concept
- Show numerical accuracy and correct rounding, and use SI units in answers

DC Circuits

You should be able to:

- ☐ Use the formula R = V/I to calculate the resistance of a conductor.
- ☐ Use the formula P =IV to calculate the power used by a conductor.
- ☐ Add resistors in series and parallel
- ☐ Calculate the E.M.F and internal resistance of various voltage loops.
- ☐ Use Kirchhoff's laws to calculate voltages and currents in one- and two-loop circuits, which may include DC voltage sources and resistors.

Capacitors in DC Circuits

You should be able to:

- ☐ Describe and explain the terms capacitance, the parallel plate capacitor, and dielectric.
- ☐ Describe the function of a capacitor in a DC circuit.
- ☐ Describe the relationship between variables affecting a parallel plate capacitor.
- ☐ Calculate the total capacitance for series and parallel capacitor combinations.
- ☐ Calculate the energy stored in a capacitor in terms of the area under the Q-V graph.
- ☐ Describe and explain capacitor charge/discharge curves (Voltage/time and current/time) in terms of accumulation of charge and comment on the meaning of the time constant.

Inductors in DC Circuits

You should be able to:

- ☐ Define the terms magnetic flux and magnetic field strength.
- ☐ Describe the factors affecting the magnetic field strength inside a solenoid.
- ☐ Describe the function of an inductor in a DC circuit.
- ☐ Describe and explain inductor charge/discharge curves (Voltage/time and current/time) and comment on the meaning of the time constant.
- ☐ Describe energy stored in an inductor.
- ☐ Describe and explain the relationship between rate of change of flux and the voltage induced across a conductor.
- ☐ Use Faraday's Law to calculate the magnitude of the Induced voltage in a coil rotating with a constant angular velocity in a uniform magnetic field.
- ☐ Apply Lenz's law to predict the direction of an induced current.
- ☐ Identify factors which affect the size and direction of the induced voltage of an inductor.
- ☐ Describe and explain the terms mutual and self- inductance.
- ☐ Describe and explain the factors which affect the size and direction of the induced voltage of an inductor.
- ☐ Describe and explain the relationship between primary (input) voltage/current and secondary (output) voltage/current in a transformer.

AC Circuits

You should be able to:

- ❑ Compare the energy dissipation of a resistor carrying DC and AC.
- ❑ Describe the difference between the RMS and peak values of current and voltage in an AC circuit.
- ❑ Describe that the current and voltage for a resistor in an AC circuit are in phase.
- ❑ Describe full and half wave rectification and smoothing in DC power supplies.
- ❑ Describe and explain why current leads p.d by 90^o in a capacitor in an RC circuit.
- ❑ Describe and explain why current lags p.d by 90^o in an inductor in an LR circuit.
- ❑ Describe and explain the terms reactance and impedance and their frequency dependence in a series circuit.
- ❑ Use equations and graphs to depict the phase and amplitude relationship of the current and voltages in an LCR series circuit.
- ❑ Describe and explain energy changes, phase relationships and the resonant condition for an inductor-capacitor-resistor series circuit.
- ❑ Describe and explain phasor diagrams to illustrate the relationship between V_{total}, V_R, V_L and V_C in an AC LCR circuit.
- ❑ Use the resistance, capacitor reactance and inductor reactance to calculate the impedance of an LCR circuit.
- ❑ Describe and explain from phasors that the alternating current in an LCR series circuit will be at a maximum when $V_L = V_C$ and use this observation to derive the resonant frequency equation f = $2\Pi\sqrt{LC}$.

Please note that the NCEA Sample paper had different equations as below:

Sample paper equations

$V = Ed$	$\Delta E = Vq$			
$E = \frac{1}{2}QV$	$\tau = RC$	$Q = CV$	$C = \frac{\varepsilon_0 \varepsilon_r A}{d}$	
$R_T = R_1 + R_2 + ...$	$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + ...$	$C_T = C_1 + C_2 + ...$	$\frac{1}{C_T} = \frac{1}{C_1} + \frac{1}{C_2} ...$	
$\phi = BA$	$\varepsilon = -L\frac{\Delta I}{\Delta t}$	$\varepsilon = -M\frac{\Delta I}{\Delta t}$	$\varepsilon = -\frac{\Delta \phi}{\Delta t}$	
$V = IR$	$P = VI$			
$\frac{N_p}{N_s} = \frac{V_p}{V_s}$	$E = \frac{1}{2}LI^2$	$\tau = \frac{L}{R}$		
$I = I_{MAX} \sin \omega t$	$V = V_{MAX} \sin \omega t$	$I_{MAX} = \sqrt{2}\, I_{rms}$	$V_{MAX} = \sqrt{2} V_{rms}$	
$X_C = \frac{1}{\omega C}$	$X_L = \omega L$	$V = IZ$	$\omega = 2\pi f$	$f = \frac{1}{T}$
$f_o = \frac{1}{2\pi\sqrt{LC}}$				