Unit 218 Electronic systems engineering

Unit summary
This unit is about the fundamentals underlying the physical operation, analysis and design of electronic circuits and systems.

Aims
The unit aims to develop the candidate's knowledge of semiconductor devices, signal amplifiers, oscillators and digital logic families.

Prerequisites
It is expected that candidates will have a working knowledge of the materials in the four compulsory papers of the Certificate examination and with other material as set out in the intended learning outcomes for subject 9107-107 Electrical and electronic engineering.

Learning outcomes
There are **three** outcomes to this unit. The candidate will be able to:

- Understand the operation and application of semiconductor devices
- Understand, analyse, design and apply analogue circuits and systems
- Understand, analyse, design and apply digital circuits and systems

Guided learning hours
It is recommended that 300 hours should be allocated for this unit. 120 of those hours are actual taught hours. This may be on a full time or part time basis.

Key Skills
No Key Skills were identified for this unit.

Occupational Standards
This unit has been mapped to the following National Occupational Standards:

1.1.1 Identify the requirements of clients for engineering products or processes
1.1.2 Produce specifications for engineering products or processes
1.4.1 Establish a design brief for engineering products or processes
1.4.3 Create designs for engineering products or processes
1.4.4 Evaluate designs for engineering products or processes
2.1.1 Determine the production requirements of engineering products and processes
2.1.2 Specify production methods and procedures to achieve production requirements
3.1.1 Determine the installation requirements for engineering products or processes
3.1.2 Specify installation methods and procedures to achieve installation requirements
4.1.1 Determine the operational requirements of engineering products or processes
6.1.1 Analyse the risks arising from engineering products and processes
6.2.1 Assure the quality of engineering products or processes
8.1.1 Maintain and develop own engineering expertise

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Outcome 1 Understand the operation and application of semiconductor devices

Knowledge requirements
The candidate knows how to:

1 understand the physical principles underlying a pn (positive/negative) junction diode and describe its V – I characteristics

2 apply large and small-signal diode models

3 understand the physical breakdown mechanisms of diodes

- a Zener diodes
- b Schottky Barrier diodes

4 understand, describe and analyse the physical operation of a bipolar junction transistor (BJT)

- a BJT operating conditions, cut-off and saturation
- b BJT small signal behaviour and the hybrid - π model
- c BJT switching properties
- d BJT as a diode
- e emitter coupled pair
- f BJT power ratings

5 understand the physical features of a FET junction field effect transistor (JFET)

- a metal-oxide semiconductor field effect transistor (MOSFET)
- b structure and physical properties
- c V-I characteristics

6 describe enhancement and depletion models

7 understand how to apply a (FET)

- a as a resistance
- b as a switch
- c as an amplifier

8 describe small signal FET models

9 develop awareness of the Ebers-Moll model and semiconductor fabrication techniques

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Outcome 2 Understand, analyse, design and apply analogue circuits and systems

Knowledge requirements
The candidate knows how to:

1 develop small signal amplifiers circuits involving
   a bipolar transistors
   b field effect transistors
2 understand biasing and current mirror circuits
3 develop transistor small signal equivalent circuits
4 develop amplifiers circuits involving
   a cascade connections
   b Darlington connections
5 develop circuits involving differential amplifiers
6 understand dynamic response of amplifiers
   a Bode diagrams
   b step response
7 understand the High Frequency hybrid - π model
8 understand the effect of coupling and bypass capacitors
9 describe the structure and operation of operational amplifiers
   a frequency response
   b slew rate
10 understand, analyse and develop operational amplifier applications
   a operational amplifiers as
      i adder
      ii integrator
      iii differentiator
   b first and second order active filters
   c logarithmic and exponential amplifiers
   d analogue multipliers
11 understand feedback amplifiers
   a feedback topologies
   b effects of negative feedback on
      i gains
      ii impedance levels
   c frequency response and distortion noise
   d stability and compensation in feedback amplifiers

12 design feedback amplifiers to meet gain, stability and bandwidth criteria

13 recognise the apply design principles for types of sinusoidal waveform oscillators

- a RC
- b LC
- c crystal

14 describe the amplitude and frequency stabilisation of waveform generators

15 describe, analyse and design circuits using

- a mono and astable multivibrators
- b Schmitt trigger circuits
- c square and triangular wave generators
- d sweep and staircase generators
- e voltage control oscillators

16 understand and analyse the operation of Class A, AB, B and C power amplifier circuits in terms of

- a power output
- b efficiency
- c distortion effects

17 understand the application and operation of rectifier circuits, regulated power supplies and switching regulators

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Outcome 3 Understand, analyse, design and apply digital circuits and systems

Knowledge requirements
The candidate knows how to:

1 understand the implementation of logic gates in integrated circuit form

2 develop awareness of fabrication technologies

3 recognise the characteristic features of the principle bipolar and metal-oxide semiconductor (MOS) logic families

- a TTL
- b ECL
- c NMOS
- d CMOS

4 understand and apply

- a Boolean theorems
- b reduction techniques
- c Karnaugh maps

to the analysis and design of combinational logic circuits having up to five variables

5 apply the above techniques to the design of

- a half and full adders
- b code converters
- c comparators
- d decoders
- e encoders
- f multiplexers

6 implement combinational logic functions using

- a programmable read only memory (PROM)
- b programmable logic array (PLA)
- c programmable array logic (PAL) structures

7 understand and apply

a state diagrams and tables

b simple state reduction methods

c excitation tables

to the analysis and design of sequential logic circuits using

a RS

b JK

c D

type flip flops

8 understand the analyse, synthesis and design of shift registers and counters

9 understand simple concepts of sampling and multiplexing for data acquisition

10 describe the structure, operation and make speed/cost comparisons for common forms of analogue-to-digital and digital-to-analogue converters

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Recommended reading list

Core texts	Author(s)	Publisher	ISBN
Digital Design Omitting Sections 3.10,3.11,5.2,5.3,7.6-7.9, chapter 8 & 9.1-9.6,9.8	Morris, Mano	Prentice Hall	013212937
Microelectronics Omitting chapter 9, sections 10.4,10.5,11.7-11.12,12.8-12.15,13.5-13.10,15.12 &15.15	Millman, Grabel	McGraw Hill	007100596