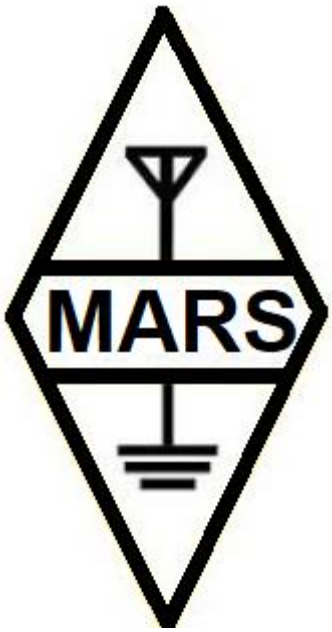


Mauritius Amateur Radio RA23 (Class A)
Student Reference Booklet

To be used by the student for a study reference

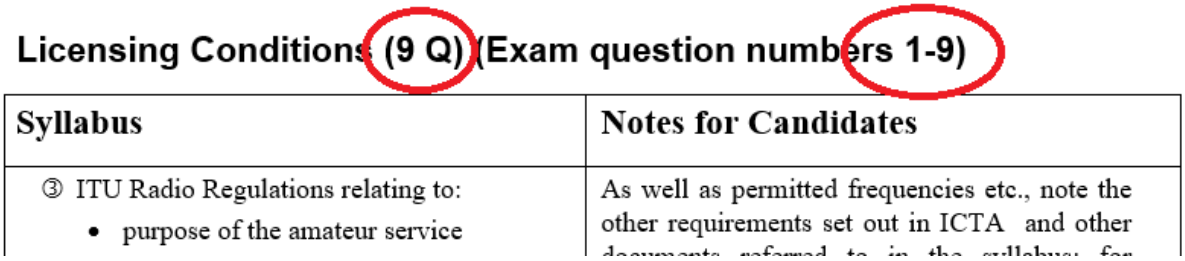
Revision date: 18/10/2020
Revision number: 1.1

Introduction

This document details the subjects tested under the ICTA RA23 (Class A) exam syllabus. You, as the student, will be able to utilise this document as a study guide for this examination.

You will see in this document tables which contain the syllabus section details in the left hand column and in the right hand column, references to where you will find some resources for covering the syllabus sections.

The header of the table also states how many questions and what question numbers these syllabus sections will appear in the actual exam.



Licensing Conditions (9 Q) (Exam question numbers 1-9)

Syllabus	Notes for Candidates
③ ITU Radio Regulations relating to: • purpose of the amateur service	As well as permitted frequencies etc., note the other requirements set out in ICTA and other

Note: You can see this example shows a total of 9 questions and will be questions 1 to 9 in the exam.

This document will be updated by M.A.R.S when new resources become available or should the exam syllabus be updated.

Exam

The RA23 exam will comprised of 60 multiple choice questions, with a period of 2 hours to complete the exam. A sample paper is available from the M.A.R.S.

Licensing Conditions (9 Q) (Exam question numbers 1-9)

Syllabus	Notes for Candidates
ITU Radio Regulations relating to: • purpose of the amateur service • emission • designations • permitted communications • use of call signs • secondary allocations National Regulations, in particular "Wireless Telegraphy (Amateur Station Licence) Licence Conditions published by ICTA In relation to the Amateur Station Operational Bands/Powers/Modes Permitted in ICTA licence conditions the syllabus requirements include; • Permitted frequencies, • Permitted modes, maximum power levels (including power levels for land mobile and maritime mobile. • Status of allocation (primary / secondary) • Entitlement to operate maritime mobile "CEPT Amateur Radio Licence" regulations regarding operation during visits to other countries participating in these arrangements	As well as permitted frequencies etc., note the other requirements set out in ICTA and other documents referred to in the syllabus: • SWR and frequency measuring devices • Log book entries • Limitations / requirements for land mobile and maritime mobile operation • Limits on non-ionising radiation and spurious emissions: it is not necessary to memorise the quantitative limits, however the aims of the limits should be understood For the CEPT amateur radio licence regulations, see "CEPT Recommendation T/R 61-01 (CEPT licences)" which is available at https://docdb.cept.org/download/e4b9c459-5726/TR61-02.pdf Students should also use their Licence conditions provided by the ICTA for licence conditions.

Operating Rules and Procedures (8 Q) (Exam question numbers 10-17)

Syllabus	Notes for Candidates
ITU Radio Regulations relating to the composition of call signs ITU radio regions National call sign prefixes [Europe and North America] – see Annex 1 IARU band plans for frequencies up to 440 MHz Distress signals, emergency traffic and natural disaster communication Format of CQ calls to specific stations Q-codes – see Annex 1 Operational abbreviations – see Annex 1 Phonetic alphabet – see Annex 1 RST code – see Annex 1	See ANNEX 1 In reviewing the band plans, note in particular the band segments for: • CW only • contest preferred • priority for intercontinental • beacons only • global emergency centre of activity Also note the accepted usage in the bands for USB and LSB.

Electrical and Electronic Principles including Components and Circuits (10Q) (Exam question numbers 18-27)

Syllabus	Notes for Candidates
DC, Resistors and Ohm's Law Meaning of the terms voltage, current, resistance and power, the units used to measure them and the relationship between them Ohm's Law and its various formulations Symbols used for the units (V, I, R, W, Ÿ, kŸ, MŸ etc.) Resistors in series and in parallel, including a combination of series and parallel resistors – current, voltage and power in these circuits Resistor accuracy and its impact on voltage, current and power Power dissipation Conductors, semi-conductors and insulators	A knowledge of Ohm's Law is essential. Ohms law online Ohms law video While simple maths may be needed to answer some questions, the "intuitive understanding" is just as important as mathematical ability. Ohms law online (2) Note that resistors determine both the current flow and the voltage drop. As well as the links above students can use the two books produced by the Radio Society of Great Britain ISBN: 9 781910 193617 ISBN: 9 781910 193624
Inductors Units (µH, mH etc.) and symbols Calculations involving series and parallel inductors The effect of number of turns, diameter, length and core material on inductance (qualitative treatment only) Inductance and inductive reactance Impedance	Only a general understanding of the effect on inductance of different physical characteristics (number of turns etc.) of inductors is expected. Inductance Online Inductance Online (2) Inductance Video Inductance Video (2) As well as the links above students can use the two books produced by the Radio Society of Great Britain ISBN: 9 781910 193617 ISBN: 9 781910 193624
Capacitors Units (µF, pF etc.) and symbols Calculations involving series and parallel capacitors The relationship between dimensions, capacitance and dielectric (qualitative treatment only) Capacitance and capacitive reactance	See the comment on inductors in relation to reactance. Capacitors Video Capacitors Online Capacitors Online (2)

Impedance, Resonance and Reactance Meaning of impedance, resonance and reactance Calculation of impedance of an inductor from resistance and reactance How reactance of an inductor and a capacitor varies with frequency Parallel and series resonant circuits □Q-factor	These topics are in effect an extension of the sections on inductors and capacitors. IRR Online Impedance Video Online Impedance Video Online (2) Impedance Video Online (3) Inductive Reactance Video Online Capacitive Reactance Video Online

Electrical and Electronic Principles including Components and Circuits (cont'd)

Syllabus	Notes for Candidates
Other Components Diodes: silicon, zener, LED and varicap Transistors: NPN, PNP, FET Transformers: isolation, step-up, step-down; turns ratio, current ratio and voltage ratio Quartz crystals Batteries Component symbols	An understanding of the purpose and the behaviour (e.g. rectification, Peak Inverse Voltage (PIV), voltage drop, amplification) of these components is required. Video 1 Video 2
Circuits Circuits and output waveforms of full-wave, halfwave and bridge rectifier power supplies, including smoothing and voltage regulation Recognise common-emitter, commoncollector/emitter-follower, common-base circuits Class A, B, A/B and C biasing	Candidates need to be generally familiar with what these simple circuits look like and their principal characteristics. In relation to biasing circuits, the key differences between the various types are in efficiency and harmonic output. Video 1
Alternating Current The unit (hertz), frequency, period, duration of period and amplitude Sine waves and square waves Ohm's Law in inductors and capacitors Relationship between peak, peak-to-peak, average and RMS value of sine waves Harmonics Phase, phase difference, phase lag and lead	A good general understanding of what is involved in alternating current (AC) is needed. Candidates should understand what a graphic representation of AC in time would look like. An understanding of how reactance is dealt with is required. A basic understanding of phasing concepts is all that is required. Video 1
Miscellaneous Amplifier gains, expressed in dB, for the following values: 0dB, 3dB, 6dB, 10dB and 20dB [both positive and negative] Digital Signal Processing (DSP): xpurpose / benefits xbasic block diagram ximportance of sampling rate LC (i.e. coil/capacitor) oscillators and crystal oscillators	Candidates should be aware that DSP is used to filter noise and audio in receivers and to synthesize signals in transmitters. Candidates should be able to recognise LC and crystal oscillator circuits and be aware of the typical usage, advantages and disadvantages of each type.

Transmitters and Receivers (7Q)(Exam question numbers 28-34)

Syllabus	Notes for Candidates
Transmitters (modes: CW, SSB, AM, FM) Generic HF station and transmitters for each mode: block diagrams and principal function of each stage Content of transmitted signals for each mode and implications for power amplifier duty cycle and rating Effect of audio modulation, where applicable Typical RF bandwidth of signals in each mode Methods of achieving frequency stability FM: modulation index, deviation, calculating total bandwidth Amplifiers including linear amplifiers and their uses Calculation of ERP (dBW) from output power (Watts), antenna gain (dB), feeder loss (dB) Purpose of ALC Output impedance	It is important to understand both the function and position (within the block diagram) of stages such as the variable frequency oscillator (VFO), buffer, driver, amplifier, balanced modulator, crystal filter, mixer, frequency multiplier, SWR meter, low pass filter, dummy load. Note that the desired transmitting frequency is often produced by mixing together the output from two or more frequency sources, and how unwanted frequencies may be produced. A broad understanding is needed of the nature of the output signal from CW, SSB, AM and FM transmissions. Note also that the modulating signal may be analogue or digital; in the case of digital signals which are continuous, note the particular need to be conscious of drive levels and transmitter ratings. A broad understanding is needed of the function and operation of linear amplifiers (including valve amplifiers). Candidates need to understand that some transmitters and most amplifiers use valves, which may have voltages in excess of 1kV applied (note the “high voltages” reference in Syllabus Section A.4 Safety)

Receivers (modes: CW, SSB, AM, FM) The superheterodyne receiver: block diagram and principal function of each stage Achieving selectivity and sensitivity Uses of the IF, BFO, AGC, CIO Image frequency / image response / high and low intermediate frequencies Typical filter bandwidths for each mode Crystal filter shape factor [ratio between the 6dB and 60db bandwidth and its effect on selectivity] Minimum discernable signal and dynamic range [basic understanding of concepts] Signal to noise ratio [basic understanding of concepts] Transverters	Candidates should understand the principles behind the design of superheterodyne receivers, along with an awareness of the function and position within the block diagram of the main (block) stages. The receiver components of interest would include the RF pre-amplifier, mixer, local oscillator, intermediate frequency (IF) amplifier, detector, beat frequency oscillator (BFO), automatic gain control (AGC), carrier insertion oscillator (CIO). Understand the concepts of selectivity, sensitivity and stability. Candidates should be familiar with the concept of image frequency – the circumstances in which it can appear and methods of minimising the consequences. They should also understand the use of high and low IF frequencies in relation to image response. In relation to transverters, a basic understanding of operation and use is all that is required.

Feeders &Antennas (7 Q) (Exam question numbers 35-41)

Syllabus	Notes for Candidates
Feeders Feeder types: open-wire (narrow-spaced, widespaced), coaxial cable, waveguide Factors determining characteristic impedance Velocity factor Standing waves: causes and consequences Open and closed stubs Antenna matching units Uses and circuit diagrams of baluns	Be aware of the implications of the feeder being matched or mis-matched to the transmitter output. The significance and typical values of feeder velocity factors should be covered. Characteristic impedance and construction of common coaxial and balanced feeders. Stubs (short pieces of feeder wire) can be used for matching antennas but note that the use of stubs also features in the section on Electromagnetic Compatibility and Transmitter Interference.

Antennas Antenna types: half-wave, quarter-wave vertical (ground plane), folded dipole, trap dipole, Yagi Physical construction (dimensions, components) Balanced and unbalanced antennas Distribution of current and voltage Impedance at the feed point Capacitive or inductive reactance of a non-resonant antenna Polarisation, directivity, efficiency and gain Effective radiated power (ERP) Front to back ratio Horizontal and vertical radiation pattern Relationship between frequency and wavelength	In order to answer questions on antennas, for each antenna type, candidates should be familiar with (where relevant) – what the antenna looks like • typical dimensions relative to operating frequency • characteristic impedance • effect of shortening or lengthening the antenna • name and positioning of the parasitic elements • how traps are constructed and their effect • voltage and current patterns radiation patterns Also understand the concepts of 'balanced' and 'unbalanced' in relation to antennas and be aware of examples of each type.

Electromagnetic Compatibility and Transmitter Interference (6Q)
(Exam questions 42-47)

Syllabus	Notes for Candidates
Interference in electronic equipment Aims of Electromagnetic Compatibility (EMC)	Electromagnetic Compatibility is the avoidance of interference between two pieces of electronic equipment.
Cause of interference in electronic equipment Field strength of the transmitter □Spurious radiation from the transmitter □Undesired influence on the equipment: • via the antenna input • via other connected lines • by direct radiation Cross modulation and intermodulation Over modulation, splatter, key clicks Overdriving linear amplifiers	Spurious radiation from a transmitter could include parasitic radiation, harmonics, unwanted mixer products, splatter, key clicks and spurious emissions. Note that the reasons for receiver interference may include – • lack of selectivity • interference received through the mains power supply • feeder problems Understand bandwidth in relation to interference. Contained within the RSGB Intermediate and Full licence books.
Measures against interference Measures to prevent and eliminate interference effects: • Filtering • Decoupling • Shielding • Location of antennas Balanced antenna systems and antenna tuning units Drive levels in linear amplifiers Operating frequency – ensuring that no part of a transmitted signal is outside band limits [respective implications for USB and LSB transmissions]	Candidates should be familiar with typical filter circuits – low pass, high pass, band pass and band reject – as well as their uses. Measure against interference would include the use of coaxial stubs and toroids. In relation to linear amplifiers, note the importance of correct drive levels and understand the consequences of incorrect drive levels.

Propagation (6 Q) (Exam question numbers 48-53)

Syllabus	Notes for Candidates
Electromagnetic waves – polarisation Atmospheric regions: troposphere, ionosphere For the troposphere and individual ionospheric layers: location, influence of the sun, effect on propagation at different frequencies Solar flares / sunspot cycles Critical frequency & maximum usable frequency (MUF) Modes of propagation: ground wave, sky wave (ionospheric wave), tropospheric wave, ducting, refraction, diffraction Angle of radiation and skip distance The influence of the height of antennas on the distance that can be covered Meteor scatter, reflections from the moon Sporadic E propagation Impact of distance on field strength for line of sight propagation Fading	When studying atmospheric regions, consider their effects on LF / HF / VHF propagation, respectively (where and at what times of the day / year are they typically situated, do they absorb or reflect? etc.). Be aware also of typical ranges for single-hop transmissions using the different layers. As regards field strength for line of sight propagation, note that there are two methods of expressing RF field strengths: • Watts per square metre (W/m^2), i.e. "power density". The power density is proportional to the inverse of the square of the distance from the source (e.g. at twice the distance you get a quarter of the power in W/m^2) • Volts per metre (V/m). Using this measurement, the power is proportional simply to the inverse of the distance from the source (e.g. at twice the distance you get half the power in V/m) In relation to fading, a basic understanding of how it occurs is all that is required.

Measurements (3 questions) (Exam question numbers 53-56)

Syllabus	Notes for Candidates
Making Measurements Measurement of DC and AC (including RF) voltage, current, resistance and power Ammeter and voltmeter: usage, internal resistance and how to extend their ranges Transmitter measurements: RF voltage, current and power, PEP (two-tone test), signal quality, spurious signals DC input power / RF output power / efficiency Usage and placement of an SWR meter Resonant frequency of a tuned circuit Impact of antenna gain and feeder loss on ERP	Because radio amateurs can build and set up their own equipment, they are obliged to be in a position to ensure that their equipment is operated within the permitted frequency bands, at permitted power levels and with appropriate signal quality etc. The ability to use suitable measuring equipment arises from this obligation. Know the efficiency of different classes of amplifiers.

Measuring Instruments Analogue and digital meters RF power meter, RMS voltmeter SWR meter Frequency measurement instruments Oscilloscope Dummy load: usage and construction	Candidates need to know where different measuring instruments should be placed in circuits – whether in series or in parallel with the current flow, at the circuit input or output etc. In relation to an oscilloscope, note in particular what is shown on the X and Y axis, respectively.

Safety (4 Q) (Exam question numbers 57-60)

Syllabus	Notes for Candidates
The human body – electric shock risks and dealing with the consequences of an electric shock • dangers of exposure to electromagnetic radiation, including hazards from antennas and waveguides • safe working conditions Minimising risks from the mains power supply, including: • the correct wiring of mains plugs • fuses and appropriate fuse ratings • isolating transformers • correct earthing procedure • use of trip switches such as Residual Current Devices (RCDs) or Earth Leakage Circuit Breakers (ELCBs) Additional precautions needed where high voltages are present Lightning protection Location of antennas Non-ionising radiation: • Sources • Health Risks • Methods of minimising adverse effects	Note that there is a regulatory requirement for radio amateurs to ensure that "…the safety of persons or property is not endangered …" • Safe working conditions would include when soldering, the requirement for good ventilation and suitable eye protection • use of secure positioning when drilling, sawing or filing • In relation to high voltages, note – the use of bleeder resistors and the discharge of smoothing capacitors • valves used in transmitters / amplifiers may have voltages in excess of 1kV • access needs to be strictly controlled • tools used to measure high voltages should be checked regularly • In relation to the location of antennas and feeders, the issues would include keeping non-ionising radiation within permitted limits • protecting against damage to persons or property • guarding against RF burns • position of overhead power lines

ANNEX 1

Principal national call sign prefixes

PREFIX	*COUNTRY*
DL	**GERMANY**
EA	**SPAIN**
EI	**IRELAND (REPUBLIC OF)**
F	**FRANCE**
GM	**SCOTLAND**
JA	**JAPAN**
ON	**BELGIUM**
PA	**NETHERLANDS**
PY	**BRAZIL**
W,K	**USA**
ZS	**SOUTH AFRICA**
3B8	**MAURITIUS**
FR	**REUNION**
5R8	**MADAGASCAR**
S79	**SEYCHELLES**

Note: Many other call sign prefixes are allocated to these countries and entities, however those listed here are the prefixes which exam candidates should be familiar with.

Q - CODES

Code	Question	Answer
QRK	What is the readability of my signals?	The readability of your signals is ...
QRM	Are you being interfered with?	I am being interfered with
QRN	Are you troubled by static?	I am troubled by static
QRO	Shall I increase transmitter power?	Increase transmitter power
QRP	Shall I decrease transmitter power?	Decrease transmitter power
QRT	Shall I stop sending?	Stop sending
QRZ	Who is calling me?	You are being called by ...
QRV	Are you ready?	I am ready
QSB	Are my signals fading?	Your signals are fading
QSL	Can you acknowledge receipt?	I am acknowledging receipt
QSO	Can you communicate with ... direct?	I can communicate ... direct
QSY	Shall I change to transmission on another frequency?	Change transmission to another frequency
QRX	When will you call again?	I will call you again at ... hours on ... kHz (or MHz)
QTH	What is your position in latitude and longitude (or according to any other indication)?	My position is ... latitude, ... longitude (or according to any other indication)

Abbreviations

BK	Signal used to interrupt a transmission in progress
CQ	General call to all stations
CW	Continuous wave
DE	From, used to separate the call sign of the station called from that of the calling station
K	Invitation to transmit
MSG	Message
PSE	Please
RST	Readability, signal-strength, tone-report
R	Received
RX	Receiver
TX	Transmitter
UR	Your

Phonetic Alphabet

A = Alpha	**J** = Juliet	**S** = Sierra
B = Bravo	**K** = Kilo	**T** = Tango
C = Charlie	**L** = Lima	**U** = Uniform
D = Delta	**M** = Mike	**V** = Victor
E = Echo	**N** = November	**W** = Whiskey
F = Foxtrot	**O** = Oscar	**X** = X-ray
G = Golf	**P** = Papa	**Y** = Yankee
H = Hotel	**Q** = Quebec	**Z** = Zulu
I = India	**R** = Romeo	

RST Code

Readability

- **R1** Unreadable
- **R2** Barely readable, occasional words distinguishable
- **R3** Readable with considerable difficulty
- **R4** Readable with practically no difficulty
- **R5** Perfectly readable

Signal Strength

- **S1** Faint signal, barely perceptible
- **S2** Very weak
- **S3** Weak
- **S4** Fair
- **S5** Fairly good
- **S6** Good
- **S7** Moderately strong
- **S8** Strong
- **S9** Very strong signals

Tone

- **T1** Extremely rough hissing note
- **T2** Very rough AC note, no trace of musicality
- **T3** Rough AC. tone, rectified but not filtered
- **T4** Rough note, some trace of filtering
- **T5** Filtered rectified AC but strongly ripple-modulated
- **T6** Filtered tone, definite trace of ripple modulation
- **T7** Near pure tone, trace of ripple modulation
- **T8** Near perfect tone, slight trace of modulation
- **T9** Perfect tone, no trace of ripple or modulation of any kind

FORMULA SHEET PROVIDED DURING THE EXAM

$R_T = R_1 + R_2 + R_3$	$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$	$V = IR$
$V_{out} = V_{in}\left(\frac{R_2}{R_1 + R_2}\right)$	$P = VI = \frac{V^2}{R} = I^2R$	$V_{rms} = \frac{V_{peak}}{\sqrt{2}}$
$C = \frac{Q}{V}$	$C = \frac{kA}{d}$ where $k = e_0 e_r$	
$\frac{1}{C_T} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$	$C_T = C_1 + C_2 + C_3$	$X_C = \frac{1}{2\pi fC}$
$L_T = L_1 + L_2 + L_3$	$\frac{1}{L_T} = \frac{1}{L_1} + \frac{1}{L_2}$	$X_L = 2\pi fL$
$Z = \sqrt{R^2 + X^2}$	$V_T = \sqrt{V_R^2 + V_C^2}$ (or V_L^2)	$f = \frac{1}{2\pi\sqrt{LC}}$
$t = \frac{1}{f}$	$\tau = CR$	$\tau = \frac{L}{R}$
$Q = \frac{2\pi fL}{R}$ or $\frac{1}{2\pi fCR}$	$Q = \frac{f_C}{f_U - f_L} = \frac{\text{centre frequency}}{\text{bandwidth}}$	$R_D = \frac{L}{CR}$
$Q = 2\pi fCR_D$		
$V_s = V_p\left(\frac{N_s}{N_p}\right)$	$I_p = I_s\left(\frac{N_s}{N_p}\right)$	$Z_p = Z_s\left(\frac{N_p}{N_s}\right)^2$
$I_C = \beta I_B$	$f_{step} = \frac{f_{crystal}}{A}$	$f_{out} = f_{crystal}\frac{N}{A}$
$c = 3\times10^8$ m/s	Gain (loss) $= 10\text{Log}_{10}\left(\frac{\text{power out}}{\text{power in}}\right)$ dB	$SWR = \frac{V_{max}}{V_{min}} = \frac{V_f + V_r}{V_f - V_r}$
$v = f\lambda$	Gain (loss) $= 20\text{Log}_{10}\left(\frac{\text{voltage out}}{\text{voltage in}}\right)$ dB	$Z_0^2 = Z_{in}\times Z_{out}$
$E = \frac{7\sqrt{erp}}{d}$	erp = power × gain (linear)	$bw = 2(AF_{max} + \Delta f)$
Return Loss $= 10\text{Log}_{10}\left(\frac{\text{Incident Power}}{\text{Reflected Power}}\right)$ dB		
Gain $= 10\text{Log}_{10}\left(\frac{\text{Power from Yagi}}{\text{Power from dipole}}\right)$ dBd	Gain $= 10\text{Log}_{10}\left(\frac{\text{Power from Yagi}}{\text{Power from isotropic}}\right)$ dBi	