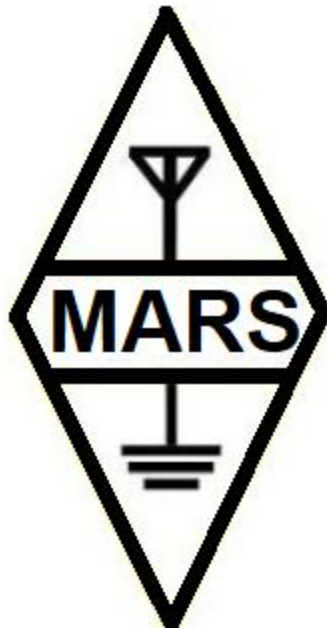


# Mauritius Amateur Radio Society

Class A Radio Amateur Examination

Syllabus and Study Framework



For examinations held as from year 2021

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# Introduction

The Mauritius Class A Radio Amateur Examination is based on the principles of the Harmonised Amateur Radio Examination Certificate (HAREC), as recommended by the International Amateur Radio Union (IARU).

The Class A examination syllabus is intended to provide a comprehensive insight to the radio amateur hobby with a commensurate advanced levels of skill and experience.

The aim of the examination is to verify and assure the examiner and regulator that successful candidates have:

Knowledge of the legal and ethical requirements of amateur radio

An understanding of safe working practices and are mindful of the safety of others

A secure basis for further study of radio science and technology

Knowledge of good operating practices and procedures

An understanding of basic electronic components and systems relevant to amateur radio

An understanding of radio communications equipment through the construction of radio related projects, fault finding and repair to a standard appropriate to the level of amateur radio licence addressed by their examination.

This syllabus sets out the requirements for an examination leading to award of a Class A Radio Amateur Licence, with full operating privileges, as determined by the Information and Communication Technologies Authority (ICTA).

# Section 1

## Operating and Licence Conditions

### 1.1 Operating

- Phonetic Alphabet
- Q-Code
- Operational Abbreviations
- International Distress Signs, Emergency traffic and natural disaster communication;
- Call signs
- IARU band plans
- Social responsibility and operating procedures
- National and International regulations relevant to the Amateur service and Amateur satellite service.

### 1.2 Licensing

- ITU Radio Regulations
- CEPT Regulations
- Licence conditions in the Republic of Mauritius

# Section 2

## Theory and Technology

### 2.1 Conductivity

- Conductor, semiconductor and insulator;
- Current, voltage and resistance;
- The units ampere, volt and ohm;
- Ohm's Law [ $E=I \cdot R$ ]
- Kirchhoff's Laws;
- Electric power [ $P=E \cdot I$ ]
- The unit watt;

- Electric energy [ $W=P \cdot t$ ]
- The capacity of a battery [ampere-hour]

## 2.2 Sources of electricity

- Voltage source, source voltage [EMF], short circuit current, internal resistance and terminal voltage;
- Series and parallel connection of voltage sources.

## 2.3 Electric field

- Electric field strength;
- The unit volt/meter;
- Shielding of electric fields.

## 2.4 Magnetic field

- Magnetic field surrounding live conductor;
- Shielding of magnetic fields.

## 2.5 Electromagnetic field

- Radio waves as electromagnetic waves;
- Propagation velocity and its relation with frequency and wavelength [ $v=f \cdot \lambda$ ]
- Polarisation.

## 2.6 Sinusoidal signals

- The graphic representation in time;
- Instantaneous value, amplitude [ $U_{\max}$ ], effective [RMS] value and average value  

$$\left[ U_{\text{eff}} = \frac{U_{\max}}{\sqrt{2}} \right]$$
- Period and duration of period;
- Frequency;
- The unit hertz;
- Phase difference.

## 2.7 Non-sinusoidal signals

- Audio signals;
- Square wave;
- The graphic representation in time;
- D.C. voltage component, fundamental wave and higher harmonics;
- Noise [ $P_N = kTB$ ] (receiver thermal noise, band noise, noise density, noise power in receiver bandwidth).

## 2.8 Modulated signals

- CW;
- Amplitude modulation;
- Phase modulation, frequency modulation and single-sideband modulation;
- Frequency deviation and modulation index  $\left[ m = \frac{\Delta F}{f_{\text{mod}}} \right]$
- Carrier, sidebands and bandwidth;
- Waveforms of CW, AM, SSB and FM signals (graphical presentation);
- Spectrum of CW, AM and SSB signals (graphical presentation);
- Digital modulations: FSK, 2-PSK, 4-PSK, QAM;
- Digital modulation: bit rate, symbol rate (Baud rate) and bandwidth;
- CRC and retransmissions (e.g. packet radio), forward error correction (e.g. Amtor FEC).

## 2.9 Power and energy

- The power of sinusoidal signals  $\left[ P = i^2 \cdot R; P = \frac{u^2}{R}; u = U_{\text{eff}}; i = I_{\text{eff}} \right]$
- Power ratios corresponding to the following dB values: 0 dB, 3 dB, 6 dB, 10 dB and 20 dB [both positive and negative];
- The input/output power ratio in dB of series-connected amplifiers and/or attenuators;
- Matching [maximum power transfer];
- The relation between power input and output and efficiency  $\left[ \eta = \frac{P_{\text{uit}}}{P_{\text{in}}} \cdot 100\% \right]$
- Peak Envelope Power [p.e.p.].

## 2.10 Digital Signal Processing (DSP)

- sampling and quantization;
- minimum sampling rate (Nyquist frequency);
- convolution (time domain / frequency domain, graphical presentation);
- anti-aliasing filtering, reconstruction filtering;
- ADC / DAC.

# Section 3

## Components

### 3.1 Resistor

- The unit ohm;
- Resistance;

- Current/voltage characteristic;
- Power dissipation.

### 3.2 Capacitor

- Capacitance;
- The unit farad;
- The relation between capacitance, dimensions and dielectric. (Qualitative treatment only);
- The reactance  $\left[ X_c = \frac{1}{2\pi f \cdot C} \right]$
- Phase relation between voltage and current.

### 3.3 Coil

- Self-inductance;
- The unit henry;
- The effect of number of turns, diameter, length and core material on inductance. (Qualitative treatment only);
- The reactance  $\left[ X_L = 2\pi f \cdot L \right]$
- Phase relation between current and voltage;
- Q-factor.

### 3.4 Transformers application and use

- Ideal transformer  $\left[ P_{\text{prim}} = P_{\text{sec}} \right]$
- The relation between turn ratio and:
  - voltage ratio  $\left[ \frac{U_{\text{sec}}}{U_{\text{prim}}} = \frac{n_{\text{sec}}}{n_{\text{prim}}} \right]$
  - current ratio  $\left[ \frac{i_{\text{sec}}}{i_{\text{prim}}} = \frac{n_{\text{prim}}}{n_{\text{sec}}} \right]$
- Impedance ratio. (Qualitative treatment only);
- Transformers.

### 3.5 Diode

- Use and application of diodes:
  - Rectifier diode, Zener diode, LED [light-emitting diode], voltage-variable and capacitor [varicap];
- Reverse voltage and leakage current.

### 3.6 Transistor

- PNP and NPN transistor;
- Amplification factor;
- Field effect vs. bipolar transistor (voltage vs. current driven);
- The transistor in the:
  - common emitter [source] circuit;
  - common base [gate] circuit;
  - common collector [drain] circuit;
- Input and output impedances of the above circuits.

### 3.7 Miscellaneous

- Simple thermionic device [valve];
- Voltages and impedances in high power valve stages, impedance transformation;
- Simple integrated circuits (include opamps).

## Section 4

### Circuits

#### 4.1 Combination of components

- Series and parallel circuits of resistors, coils, capacitors, transformers and diodes;
- Current and voltage in these circuits;
- Behaviour of real (non-ideal) resistor, capacitor and inductors at high frequencies.

#### 4.2 Filter

- Series-tuned and parallel-tuned circuit:
- Impedance;
- Frequency characteristic;
- Resonance frequency  $\left[ f = \frac{1}{2\pi\sqrt{LC}} \right]$
- Quality factor of a tuned circuit  $\left[ Q = \frac{2\pi f \cdot L}{R_s}; Q = \frac{R_p}{2\pi f \cdot L}; Q = \frac{f_{res}}{B} \right]$
- Bandwidth;
- Band-pass filter;
- Low-pass, high-pass, band-pass and band-stop filters composed of passive elements;
- Frequency response;
- Pi filter and T filter;
- Quartz crystal;

- Effects due to real (=non-ideal) components;
- Digital filters (see sections 1.10 and 3.8).

#### 4.3 Power supply

- Circuits for half-wave and full-wave rectification and the Bridge rectifier;
- Smoothing circuits;
- Stabilization circuits in low voltage supplies;
- Switching mode power supplies, isolation and EMC.

#### 4.4 Amplifier

- Lf and hf amplifiers;
- Gain;
- Amplitude/frequency characteristic and bandwidth (broadband vs. tuned stages);
- Class A, A/B, B and C biasing;
- Harmonic and intermodulation distortion, overdriving amplifier stages.

#### 4.5 Detector

- AM detectors (envelope detectors);
- Diode detector;
- Product detectors and beat oscillators;
- FM detectors.

#### 4.6 Oscillator

- Feedback (intentional and unintentional oscillations);
- Factors affecting frequency and frequency stability conditions necessary for oscillation;
- LC oscillator;
- Crystal oscillator, overtone oscillator;
- Voltage controlled oscillator (VCO);
- Phase noise.

#### 4.7 Phase Locked Loop [PLL]

- Control loop with phase comparator circuit;
- Frequency synthesis with a programmable divider in the feedback loop.

#### 4.8 Digital signal processing (DSP systems)

- FIR and IIR filter topologies;
- Fourier Transformation (DFT; FFT, graphical presentation);
- Direct Digital Synthesis.



# Section 5

## Receivers

### 5.1 Types

- Single and double super heterodyne receiver;
- Direct conversion receivers.
- Software Define Radio ( SDR )

### 5.2 Block diagrams

- CW receiver [A1A];
- AM receiver [A3E]
- SSB receiver for suppressed carrier telephony [J3E];
- FM receiver [F3E]

### 5.3 Operation and function of the following stages (Block diagram treatment only)

- HF amplifier [with tuned or fixed band pass];
- Oscillator [fixed and variable];
- Mixer;
- Intermediate frequency amplifier;
- Limiter;
- Detector, including product detector;
- Audio amplifier;
- Automatic gain control;
- S meter;
- Squelch.

### 5.4 Receiver characteristics (simple description treatment)

- Adjacent-channel;
- Selectivity;
- Sensitivity, receiver noise, noise figure;
- Stability;
- Image frequency;
- Desensitization / Blocking;
- Intermodulation; cross modulation;
- Reciprocal mixing [phase noise].

# Section 6

## Transmitters

### 6.1 Types

- Transmitter with or without frequency translation.

### 6.2 Block diagrams

- CW transmitter [A1A];
- SSB transmitter with suppressed carrier telephony [J3E];
- FM transmitter with the audio signal modulating the VCO of the PLL [F3E].

### 6.3 Operation and functions of the following stages (Block diagram treatment only)

- Mixer;
- Oscillator;
- Buffer;
- Driver;
- Frequency multiplier;
- Power amplifier;
- Output matching;
- Output filter;
- Frequency modulator;
- SSB modulator;
- Phase modulator;
- Crystal filter.

### 6.4 Transmitter characteristics (simple description)

- Frequency stability;
- RF-bandwidth;
- Sidebands;
- Audio-frequency range;
- Non-linearity [harmonic and intermodulation distortion];
- Output impedance;
- Output power;
- Efficiency;
- Frequency deviation;
- Modulation index;
- CW key clicks and chirps;

- SSB over modulation and splatter (agreed);
- Spurious RF radiations (agreed);
- Cabinet radiations;
- Phase noise.

## Section 7

### Antennas and transmission lines

#### 7.1 Antenna types

- Centre fed half-wave antenna;
- End fed half-wave antenna;
- Folded dipole;
- Quarter-wave vertical antenna [ground plane];
- Antenna with parasitic elements [Yagi];
- Aperture antennas (Parabolic reflector, horn);
- Trap dipole.

#### 7.2 Antenna characteristics

- Distribution of the current and voltage;
- Impedance at the feed point;
- Capacitive or inductive impedance of a non-resonant antenna;
- Polarisation;
- Antenna directivity, efficiency and gain;
- Capture area;
- Radiated power [ERP, EIRP];
- Front-to-back ratio;
- Horizontal and vertical radiation patterns.

#### 7.3 Transmission lines

- Parallel conductor line;
- Coaxial cable;
- Waveguide;
- Characteristic impedance [ $Z_0$ ];
- Velocity factor;
- Standing-wave ratio;
- Losses;
- Balun;
- Antenna tuning units (pi and T configurations only).

## Section 8

### Propagation

- Signal attenuation, signal to noise ratio;
- Line of sight propagation (free space propagation, inverse square law);
- Ionospheric layers;
- Critical frequency;
- Influence of the sun on the ionosphere;
- Maximum Usable Frequency;
- Ground wave and sky wave, angle of radiation and skip distance;
- Multipath in ionospheric propagation;
- Fading;
- Troposphere (Ducting, scattering);
- The influence of the height of antennas on the distance that can be covered [radio horizon];
- Temperature inversion;
- Sporadic E-reflection;
- Auroral scattering;
- Meteor scatter;
- Reflections from the moon;
- Atmospheric noise [distant thunderstorms];
- Galactic noise;
- Ground (thermal) noise.
- Propagation prediction basics (link budget):
- dominant noise source, (band noise vs. receiver noise) ;
- minimum signal to noise ratio;
- minimum received signal power;
- path loss;
- antenna gains, transmission line losses;
- minimum transmitter power.

## Section 9

### Measurements

## 9.1 Making measurements

- Measurement of:
- DC and AC voltages and currents;
- Measuring errors:
- Influence of frequency;
- Influence of waveform;
- Influence of internal resistance of meters.
- Resistance;
- DC and RF power [average power, Peak Envelope Power];
- Voltage standing-wave ratio;
- Waveform of the envelope of an RF signal;
- Frequency;
- Resonant frequency.

## 9.2 Measuring instruments

- Making measurements using:
- Multi range meter (digital and analog);
- Rf-power meter;
- Reflectometer bridge (SWR meter);
- Signal generator;
- Frequency counter;
- Oscilloscope;
- Spectrum Analyzer.

# Section 10

## Interference and Immunity

### 10.1 Interference in electronic equipment

- Blocking
- Interference with the desired signal
- Intermodulation
- Detection in audio circuits

### 10.2 Cause of interference in electronic equipment

- Field strength of the transmitter
- Spurious radiation of the transmitter [parasitic radiation, harmonics]
- Undesired influence on the equipment:

- via the antenna input [aerial voltage, input selectivity]
- via other connected lines
- by direct radiation

### 10.3 Measures against interference

- Measures to prevent and eliminate interference effects:
- Filtering
- Decoupling
- Shielding

## Section 11

### Safety

- The human body
- Mains power supply
- High voltages
- Lightning

In addition to the above criteria the following material will also be examinable.

### Phonetic Alphabet

A = Alpha	J = Juliett	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	

## Q-Code

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 ... 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
DX	Long distance

The RA23 exam will be managed and administered by the Mauritius Amateur Radio Society (M.A.R.S) on behalf of the I.C.T.A in a mutually agreed format.

### Key Features

Part of a progressive system of learning designed to promote an understanding of radio communications science, technology and practice sufficient to allow the licensed operator to work safely on the amateur radio bands.

Clear presentation of content for easy reference.

The examination program as a whole provides a backbone of theoretical knowledge whilst at the same time requiring 'On-air' experience and practical skills.

A student's workbook (similar to the UK RSGB examination framework) is available covering the syllabus and is suitable for self-study if desired.

Can be used within schools and youth organisations to enrich the Science and Technology curricula.

### The Assessment

The syllabus outlines the requirement to demonstrate knowledge and understanding of advanced techniques in the use of radio transmitter/receiver equipment, correct on-air operating procedures and both national and international licencing regulations.

The examination is a written examination of 60 multiple-choice questions, each with 4 possible answers, based on the Class A syllabus. The time allowed for the examination will be two hours (120 minutes).

Class A (RA23)



Examination results will be notified to the ICTA licensing department. Candidates must use the ICTA appropriate Radio Amateur licence application form when applying for a licence. .

Examinations will be carried out at a MARS DESIGNATED examination Centre.

### Prior Learning and Progression

A pass of the Class B examination is an entry requirement for the Class A examination program. There are no set age limits for commencing study, although it should be noted that the minimum age to hold a Radio Amateur licence in Mauritius is 16 years of age.

### Candidates with disabilities

Arrangements can be made for candidates with disabilities to demonstrate skills and knowledge by whatever means is judged appropriate. Where critical skills, such as on-air operation, are involved the requirement can be modified to reflect the candidate's normal method of working.

Applications for special arrangements should be made well in advance of the examination to the Mauritius Amateur Radio Society (MARS) and will normally require a medical certificate advising the appropriate method of assessment or examination. Any waiver granted will be shown on the registration document issued by the MARS Examination Committee.

Appeals after the examination citing disabilities or learning difficulties not previously declared cannot be considered.

Secretary

Mauritius Amateur Radio Society

6 Shastri Road

Candos

Quatre Bornes

### Pass Mark

The pass mark is 60% or 36 correct questions out of a total of 60.

### Language

The language of assessment will be English.

A sample question paper can be obtained from the Secretary of MARS.

### Updates

Updates to this syllabus may be made from time to time, as the syllabus framework is based on recommendations of the ITU IARU document T/R 61-02 Edition 5 published on 5 February 2016 (and any subsequent revisions) for the guidance of the administrations in preparation of their national amateur radio examinations for the CEPT Harmonised Amateur Radio Examination Certificate (HAREC).

Where an update involves a significant change to the syllabus content, the date from which the syllabus is valid for examinations will be amended to show the new period of validity of the syllabus. A minimum of three months' notice will be given.

Changes to the licence schedule and band plans should not affect the examination because those documents are provided to candidates for reference. It should also be noted that the band plans referenced in the examination are based on those issued by the IARU Region 1 and relevant to Mauritius.

Class A (RA23)