Teacher Resource Bank

GCE Electronics

Scheme of Work A2
A2 Electronics – possible teaching schemes

Introduction

Schemes of work are of an individual nature and represent the way in which the requirements of the specification may be adapted to meet the needs of the specific teaching situation. This section can do no more than offer general guidance and advice. All items included are suggestions only and are by no means prescriptive.

General points

In producing a scheme of work from this specification, you should bear the following points in mind.

- In addition to acquiring factual material, candidates will need to practise the application of knowledge and interpretation of data.
- Candidates who have followed an AS Electronics course the previous year will have already developed skills useful in the coursework assessment.

Projects

The timing of the project work, ELEC6, will be an important part of planning the scheme of work. Projects need to be completed, tested and demonstrated; the reports need to be assessed and sent to the AQA Moderator by 15th May. Depending on the facilities available in the centre, you may specially want to run the A2 project work either in parallel with, or before, the AS project work. There are various approaches to consider, e.g.:

- devote half of the lessons in a week to projects, while carrying on with the theory units in the others;
- devote all lessons and homework in a period of weeks to projects;
- spend 2-3 weeks on the research and design phases, assess this and cover more of the content, then spend 2-3 weeks on the build and test phases.

If ELEC4 and ELEC5 are not completed before starting project work, possibilities are e.g.:

- select topics to complete which are particularly relevant to many projects;
- do an overview of all theory, coming back to cover it in full detail later;
- refer students to the Support Booklets (available at http://www.ikes.freeserve.co.uk) where this would be helpful for their particular project.

Kits

It will be important for students to be introduced to available kit, such as microcontrollers, robotics, radio transmitters/receivers, displays, which they might find useful for project work. These are available from the usual electronics suppliers. The teacher or technician can easily make some modules for demonstration or experiment.

Approaches

The following schemes are possible approaches to planning the year. There are some suggestions for experimental work at each stage. It is assumed that the teachers and students will use the Support Booklets (available at http://www.ikes.freeserve.co.uk) to help with the theoretical background. To avoid making the schemes appear unnecessarily complex, the project has been included as a five week block, although there are various ways of timetabling it, as indicated above.
Scheme 1 starts with the Programmable Control Systems Unit. Then the general principles of communication systems, audio systems, digital communication. Radio communication and radio receivers are left until after the project work. Although a radio system may well form part of a student’s project, the theory of its operation may not be required; students can be referred to the Student Support Booklet, if necessary.

Scheme 2 is more interleaved. It starts with radio communication, then looks at programming microcontrollers, as a taste of both units. Then digital communication, input/output subsystems, audio systems. Weeks at the end of the course, after the project work, are used to clarify some general principles and finish other parts of the units. This is not to imply that these sections cannot form part of a student’s project work.
# SCHEME OF WORK 1

<table>
<thead>
<tr>
<th>week no</th>
<th>topic</th>
<th>detail</th>
<th>notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Control Systems</td>
<td>• describe the features of the generalised control system shown below;</td>
<td>look at examples of systems demonstrate audio feedback (positive)</td>
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<tr>
<td></td>
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<td>• distinguish between open and closed loop control systems and describe their characteristics;</td>
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<td>• describe what is meant by feedback in a control system and give examples of systems with feedback;</td>
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<td>• distinguish between positive and negative feedback in control systems and describe the characteristics of each.</td>
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<td><img src="image" alt="Control System Diagram" /></td>
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<tr>
<td>2</td>
<td>Micro-processor Subsystems</td>
<td>• describe the relative merits of hardwired systems and software controlled systems;</td>
<td>look at data sheets for microcontrollers</td>
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<tr>
<td></td>
<td></td>
<td>• describe the architecture of a generalised microprocessor control system consisting of microprocessor, clock, memory (ROM and RAM) and input/output ports, connected by a bus structure;</td>
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<td>• describe the architecture of a generic single chip microcontroller;</td>
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<td></td>
<td>• describe the social and economic benefits and implications of the use of microcontrollers.</td>
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</tr>
</tbody>
</table>
| 3-5 | Programming | • analyse a process into a sequence of fundamental operations;  
• convert a sequence of fundamental operations into a flow chart;  
• interpret flow charts and convert them into a generic microcontroller program;  
• recognise and use a limited range of assembler language microcontroller instructions (see Data Sheet);  
• write subroutines to:  
  - configure the input and output pins  
  - read data from a sensor  
  - write data to an output device  
  - give a specified time delay  
  - give a specified sequence of control signals  
  - perform simple arithmetic and logic operations  
  - detect events using polling and hardware interrupts;  
• compare the use of hardware interrupts and polling to trigger events;  
• interpret programs written with a limited range of assembler instructions. | introduce the microcontroller system which is available for projects |
| 6,7 | Input Subsystems | • draw a block diagram for an 8-bit digital ramp Analogue to Digital Converter, ADC, and explain its operation;  
• describe uses of an ADC;  
• describe the limitations of this type of ADC;  
• describe the circuit for a Flash ADC and explain its operation;  
• calculate component values for a Flash ADC;  
• compare the relative merits of flash ADCs and digital ramp ADCs;  
• describe the use and operation of reflective and slotted optical switches;  
• describe the use and operation of a slotted disk shaft encoder;  
• describe the use and operation of a binary coded shaft encoder;  
• explain why a Gray coded shaft encoder is preferred in practice to a binary coded encoder. | make a digital ramp generator, using either software or binary counter, and a DAC  
make a simple window comparator  
look at slotted disk encoder in a mechanical mouse |
| 8,9 | Output Subsystems | • describe the circuit for an 8-bit Digital to Analogue Converter, DAC, based on a summing amplifier and explain its operation;  
• describe uses of a DAC;  
• calculate component values for a DAC;  
• calculate the output voltage from a DAC;  
• describe the use and operation of multiplexed seven segment displays (LCD and LED);  
• describe the use and operation of multiplexed dot matrix displays;  
• describe the different types of stepper motor;  
• describe the use and operation of stepper motors;  
• describe the essential differences in operation between conventional motors and stepper motors. | build a 3-bit DAC using a summing amplifier;  
program a microcontroller to drive a 7-segment display, a dot matrix display;  
program a microcontroller to drive a stepper motor. |
| --- | --- | --- | --- |
| 10 | Interfacing Subsystems | • describe the use of tri-state buffers;  
• describe the use of data latches;  
• describe how data latches can be constructed from D-type flip-flops;  
• recall the circuits for inverting Schmitt triggers and describe their operation;  
• calculate the switching levels for inverting Schmitt triggers;  
• explain how a Schmitt trigger can be used to regenerate a noisy input signal;  
• describe the circuits needed to drive multiplexed displays (LCD and LED);  
• recall the circuit for an H-bridge driver and describe its use and operation;  
• describe the circuits needed to drive both conventional and stepper motors. | make op-amp Schmitt trigger circuits; use alternating input and X-Y display on an oscilloscope to show the characteristic. |
| 11 | Robotic Systems | • describe the essential components of robotic systems sensors, actuators and control architectures;  
• describe the merits and suitability of different power sources;  
• design control algorithms for a robotic system to achieve a given objective;  
• describe the ability of such systems to sustain artificially intelligent behaviour through the use of artificial neural networks;  
• discuss the applications of robotic systems;  
• describe the social and economic impact of robotic systems;  
• describe possible future developments of robotic systems. | simple robot kits are available from the usual electronics suppliers. |
| 12 | General Principles of Communication Systems | • know and understand that communication is the transfer of meaningful information from one location to another;  
• draw a block diagram, understand and explain the operation of a generalised communication system, consisting of input transducer, carrier generator, modulator/encoder, transmitter, transmission link (medium), receiver, demodulator/decoder, output transducer;  
• compare, in qualitative terms, the transmission of electromagnetic signals along a twisted pair, coaxial cable, optical fibre, and in free space;  
• understand and apply the relationship between bandwidth and capacity to carry information;  
• understand the need to multiplex a number of signals onto one transmission medium;  
• describe and understand the principles of frequency division multiplexing and time division multiplexing;  
• recall and describe the difference between noise, distortion and crosstalk;  
• calculate, and appreciate the significance of, signal-to-noise ratio (in dB). |
|---|---|---|
| 13, 14 | Audio Systems | • calculate the reactance of a capacitor using the formula \[ X_C = \frac{1}{2\pi fC} \]  
• draw, analyse and explain passive high pass and low pass filters using RC circuits;  
• calculate the breakpoint frequency of passive filter circuits;  
• draw, analyse and explain first order active filters based on an inverting op-amp, including treble cut, treble boost, bass cut and bass boost;  
• calculate the breakpoint frequency of active filter circuits;  
• calculate the values of components in an active filter circuit for a given breakpoint frequency;  
• describe and explain the use of common audio power IC amplifiers.  
measure how current varies with frequency  
for a capacitor  
plot characteristics of a passive filter  
make active filters |
| 15 | Digital Communication | • compare the relative merits of analogue and digital communication;  
• describe and illustrate the following pulse modulation techniques and describe the subsystems required to produce them from an analogue signal:  
  - pulse amplitude modulation (PAM)  
  - pulse width modulation (PWM)  
  - pulse position modulation (PPM)  
  - pulse code modulation (PCM)  
• explain how the sampling rate and resolution affect the bit rate and perform appropriate calculations;  
• discuss the relative merits of half and full duplex communication links;  
• discuss the relative merits of serial and parallel data transmission;  
• discuss the relative merits of synchronous and asynchronous transmission;  
• describe the use of start and stop bits, and a parity bit;  
• calculate bit and baud rate;  
• describe the ideas of packet switching;  
| 16 |  |  
| 17 | Optoelectronics | • describe how optical fibres are constructed and work;  
• understand the use of total internal reflection in optical fibre systems;  
• describe the effect of attenuation, dispersion and radiation on an optical digital signal;  
• describe the use of a laser diode as a light source and the use of PIN diodes as detectors (detailed knowledge of devices not required).  
| 18-22 | ELEC6 | PROJECT – 20 hours of class time  
|  |  | PWM and PCM can be produced using a simple program on a microcontroller control brightness of a lamp or LED using PWM  
|  |  | build a shift register using D-type flip-flops  
|  |  | build a 2 to 1 multiplexer using gates  
|  |  | demonstrate data transmission down an optical fibre  
<p>|  |  | must be completed and marks submitted by 15th May may be necessary to leave some topics until after project |</p>
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<td>• describe the transfer of data by different types of carriers and media;</td>
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<td>• explain the need for a carrier wave;</td>
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<td>• explain how the signal amplitude and frequency are encoded on the carrier using amplitude modulation (AM);</td>
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<td>• draw time waveforms to illustrate the nature of AM including the effect of depth of modulation on the envelope;</td>
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<td>• draw and label a frequency spectrum for a sinusoidal carrier wave amplitude modulated by:</td>
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<td>- a single frequency signal, showing the carrier and side frequencies</td>
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<td>- a signal consisting of a range of frequencies, showing the carrier and sidebands</td>
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<td>• explain and calculate the bandwidth requirements of AM signals;</td>
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<td>radio transmitter / receiver modules are available from the usual electronics suppliers look at AM waveforms on an oscilloscope</td>
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<td><strong>24</strong></td>
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<tr>
<td></td>
<td>• explain how a signal’s amplitude and frequency are encoded on the carrier using frequency modulation (FM);</td>
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<tr>
<td></td>
<td>• draw time waveforms to illustrate the nature of FM;</td>
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<tr>
<td></td>
<td>• describe and calculate the practical bandwidth requirements of FM signals;</td>
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<tr>
<td></td>
<td>• know that radio stations broadcasting in LF and MF bands use AM;</td>
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<tr>
<td></td>
<td>• describe channel allocation within LF and MF broadcasting;</td>
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<td></td>
<td>• know that FM is used for entertainment broadcasting in the 88 MHz – 108 MHz VHF band;</td>
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<tr>
<td></td>
<td>• understand and explain the relationship between channel spacing and signal bandwidth;</td>
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<td></td>
<td>• know that DAB broadcasting is used in the 217.5 MHz – 230 MHz VHF band, and that channels are grouped in multiplexes on different frequencies;</td>
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<td></td>
<td>• explain why different DAB channels are transmitted at different data rates, depending on the programme content.</td>
</tr>
<tr>
<td></td>
<td>look at data for transmitters in your area look at AM waveforms on an oscilloscope look at data for multiplexes in your area</td>
</tr>
</tbody>
</table>
| 25 | Radio Receivers | • describe and explain the function of the systems within a simple radio receiver, consisting of an aerial, tuned circuit, detector/demodulator and earphone;  
• calculate the optimum length for a half-wave dipole for a given wavelength/frequency;  
• know that the impedance of the antenna should match that of the feed;  
• describe in qualitative terms, how voltage and current vary in a parallel LC circuit near resonance;  
• know that resonance occurs when \( X_L = X_C \) and hence calculate the resonant frequency;  
• draw a resonance curve for a parallel LC circuit;  
• explain the use of an LC network to select a particular frequency;  
• explain the significance of the quality factor of a tuned circuit and its relationship to the selectivity of the receiver;  
• use the resonant frequency formula \( f = \frac{1}{2\pi\sqrt{LC}} \) to calculate suitable values of L and C;  
• explain how an rf amplifier can be used to improve sensitivity;  

make a ‘crystal set’ radio

make measurements on a resonant circuit (usually easier in the audio frequency range)

| 26 | Superhet | • draw a block diagram for a superhet receiver consisting of an aerial, rf amplifier, local oscillator, mixer, if amplifier and filter, demodulator, AGC, af amplifier and loudspeaker;  
• describe the principle of operation of the superhet;  
• describe the frequency spectrum at the output of the mixer, limited to the main mixer products of the two input frequencies and the sum and difference frequencies;  
• describe the advantages and disadvantages of the superhet receiver over a simple receiver;  

look at waveforms in a superhet circuit

| 27 | Mobile Communication | • understand that mobile telephones are connected to the main telephone network via a radio link to a nearby base station;  
• understand how a large number of mobile telephones can be used within a restricted frequency allocation;  
• calculate the maximum number of mobile telephones that can be supported on one cell given the size of the cell and the available bandwidth;  
• understand the meaning of the following terms: repeater, regenerator, cellular, frequency reuse;  
• describe situations in which mobile communications can affect everyday life.  

find locations and networks of local mobile telephone masts

| 28-30 | | Revision, past papers, practice exam, etc. |
### SCHEME OF WORK 2

<table>
<thead>
<tr>
<th>week no</th>
<th>topic</th>
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<tbody>
<tr>
<td>1</td>
<td>Radio Communication – General Principles AM</td>
<td>describe the transfer of data by different types of carriers and media; explain the need for a carrier wave; explain how the signal amplitude and frequency are encoded on the carrier using amplitude modulation (AM); draw time waveforms to illustrate the nature of AM including the effect of depth of modulation on the envelope; draw and label a frequency spectrum for a sinusoidal carrier wave amplitude modulated by: - a single frequency signal, showing the carrier and side frequencies - a signal consisting of a range of frequencies, showing the carrier and sidebands explain and calculate the bandwidth requirements of AM signals; radio transmitter/receiver modules are available from the usual electronics suppliers look at AM waveforms on an oscilloscope</td>
<td></td>
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<tr>
<td>2</td>
<td>FM, DAB</td>
<td>explain how a signal’s amplitude and frequency are encoded on the carrier using frequency modulation (FM); draw time waveforms to illustrate the nature of FM; describe and calculate the practical bandwidth requirements of FM signals; know that radio stations broadcasting in LF and MF bands use AM; describe channel allocation within LF and MF broadcasting; know that FM is used for entertainment broadcasting in the 88 MHz – 108 MHz VHF band; understand and explain the relationship between channel spacing and signal bandwidth; know that DAB broadcasting is used in the 217.5 MHz – 230 MHz VHF band, and that channels are grouped in multiplexes on different frequencies; explain why different DAB channels are transmitted at different data rates, depending on the programme content. look at data for transmitters in your area look at AM waveforms on an oscilloscope look at data for multiplexes in your area</td>
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### 3 Radio Receivers

- describe and explain the function of the systems within a simple radio receiver, consisting of an aerial, tuned circuit, detector/demodulator and earphone;
- calculate the optimum length for a half-wave dipole for a given wavelength/frequency;
- know that the impedance of the antenna should match that of the feed;
- describe in qualitative terms, how voltage and current vary in a parallel LC circuit near resonance;
- know that resonance occurs when \( X_L = X_C \) and hence calculate the resonant frequency;
- draw a resonance curve for a parallel LC circuit;
- explain the use of an LC network to select a particular frequency;
- explain the significance of the quality factor of a tuned circuit and its relationship to the selectivity of the receiver;
- use the resonant frequency formula \( f = \frac{1}{2\pi\sqrt{LC}} \)
  
  to calculate suitable values of \( L \) and \( C \);
- explain how an rf amplifier can be used to improve sensitivity;

### 4-6 Programming

- analyse a process into a sequence of fundamental operations;
- convert a sequence of fundamental operations into a flow chart;
- interpret flow charts and convert them into a generic microcontroller program;
- recognise and use a limited range of assembler language microcontroller instructions (see Data Sheet);
- write subroutines to:
  - configure the input and output pins
  - read data from a sensor
  - write data to an output device
  - give a specified time delay
  - give a specified sequence of control signals
  - perform simple arithmetic and logic operations
  - detect events using polling and hardware interrupts;
- compare the use of hardware interrupts and polling to trigger events;
- interpret programs written with a limited range of assembler instructions.

- make a ‘crystal set’ radio
- make measurements on a resonant circuit (usually easier in the audio frequency range)
- introduce the microcontroller system which is available for projects
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<td>• describe the ideas of packet switching;</td>
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<tbody>
<tr>
<td>• explain the operation and use of serial and parallel shift registers and draw their respective timing diagrams;</td>
<td><strong>build a shift register using D-type flip-flops.</strong></td>
</tr>
<tr>
<td>• explain the action of a multiplexer;</td>
<td><strong>build a 2 to 1 multiplexer using gates.</strong></td>
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<tr>
<td>• describe the use of multiplexers for serial data transmission;</td>
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</tr>
<tr>
<td>• design and describe logic diagrams, truth tables and Boolean algebra relating to 2 to 1 and 4 to 1 multiplexers;</td>
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</tr>
<tr>
<td>• explain how a Schmitt trigger can be used to regenerate a digital signal qualitatively.</td>
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</table>

<table>
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<tr>
<th>9</th>
<th>Optoelectronics</th>
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<td>• describe how optical fibres are constructed and work;</td>
<td><strong>demonstrate data transmission down an optical fibre.</strong></td>
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<td>• describe the use of a laser diode as a light source and the use of PIN diodes as detectors (detailed knowledge of devices not required).</td>
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### Input Subsystems

- draw a block diagram for an 8-bit digital ramp Analogue to Digital Converter, ADC, and explain its operation;
- describe uses of an ADC;
- describe the limitations of this type of ADC;
- describe the circuit for a Flash ADC and explain its operation;
- calculate component values for a Flash ADC;
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- describe the use and operation of reflective and slotted optical switches;
- describe the use and operation of a slotted disk shaft encoder;
- describe the use and operation of a binary coded shaft encoder;
- explain why a Gray coded shaft encoder is preferred in practice to a binary coded encoder.

### Output Subsystems

- describe the circuit for an 8-bit Digital to Analogue Converter, DAC, based on a summing amplifier and explain its operation;
- describe uses of a DAC;
- calculate component values for a DAC;
- calculate the output voltage from a DAC;
- describe the use and operation of multiplexed seven segment displays (LCD and LED);
- describe the use and operation of multiplexed dot matrix displays;
- describe the different types of stepper motor;
- describe the use and operation of stepper motors;
- describe the essential differences in operation between conventional motors and stepper motors.

### Interfacing Subsystems

- describe the use of tri-state buffers;
- describe the use of data latches;
- describe how data latches can be constructed from D-type flip-flops;
- recall the circuits for inverting Schmitt triggers and describe their operation;
- calculate the switching levels for inverting Schmitt triggers;
- explain how a Schmitt trigger can be used to regenerate a noisy input signal;
- describe the circuits needed to drive multiplexed displays (LCD and LED);
- recall the circuit for an H-bridge driver and describe its use and operation;
- describe the circuits needed to drive both conventional and stepper motors.
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<td>• calculate, and appreciate the significance of, signal-to-noise ratio (in dB).</td>
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| 23 | Superhet | • draw a block diagram for a superhet receiver consisting of an aerial, rf amplifier, local oscillator, mixer, if amplifier and filter, demodulator, AGC, af amplifier and loudspeaker;  
• describe the principle of operation of the superhet;  
• describe the frequency spectrum at the output of the mixer, limited to the main mixer products of the two input frequencies and the sum and difference frequencies;  
• describe the advantages and disadvantages of the superhet receiver over a simple receiver. | look at waveforms in a superhet circuit |
| 24 | Mobile Communication | • understand that mobile telephones are connected to the main telephone network via a radio link to a nearby base station;  
• understand how a large number of mobile telephones can be used within a restricted frequency allocation;  
• calculate the maximum number of mobile telephones that can be supported on one cell given the size of the cell and the available bandwidth;  
• understand the meaning of the following terms: repeater, regenerator, cellular, frequency reuse;  
• describe situations in which mobile communications can affect everyday life. | find locations and networks of local mobile telephone masts |
| 25 | Control Systems | • describe the features of the generalised control system shown below;  
• distinguish between open and closed loop control systems and describe their characteristics;  
• describe what is meant by feedback in a control system and give examples of systems with feedback;  
• distinguish between positive and negative feedback in control systems and describe the characteristics of each. | look at examples of systems demonstrate audio feedback (positive) |
| 26  | Microprocessor Subsystems               | • describe the relative merits of hardwired systems and software controlled systems;  
• describe the architecture of a generalised microprocessor control system consisting of microprocessor, clock, memory (ROM and RAM) and input/output ports, connected by a bus structure;  
• describe the architecture of a generic single chip microcontroller;  
• describe the social and economic benefits and implications of the use of microcontrollers. | look at data sheets for microcontrollers |
|-----|----------------------------------------|---------------------------------------------------------------------------------|-------------------------------------------|
| 27  | Robotic Systems                        | • describe the essential components of robotic systems sensors, actuators and control architectures;  
• describe the merits and suitability of different power sources;  
• design control algorithms for a robotic system to achieve a given objective;  
• describe the ability of such systems to sustain artificially intelligent behaviour through the use of artificial neural networks;  
• discuss the applications of robotic systems;  
• describe the social and economic impact of robotic systems;  
• describe possible future developments of robotic systems. | simple robot kits are available from the usual electronics suppliers |
| 28-30 | Revision, past papers, practice exam, etc. |                                                                                   |                                           |