Teacher Resource Bank

GCE Electronics
Schemes of Work
SCHEMES OF WORK

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.

- Study leave, the ‘half-term’ holiday and the AS examinations in May mean that the effective time available for teaching the AS may be shorter than that potentially available for A2.
- Candidates generally need more support and the pace of delivery needs to be slower at the start of the course.
- In addition to acquiring factual material, candidates will need to practise the application of knowledge and interpretation of data.
- Time may need to be set aside for generating evidence for Key Skills Qualifications.
- Candidates need the opportunity to develop the skills that will be useful in the coursework assessment.

Projects
The timing of the project work, ELEC3, 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.

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 ELEC1 and ELEC2 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
Although students will need to be introduced to the use of protoboard at an early stage, many have some difficulty in connecting circuits on it, and it may not be suitable for introducing concepts such as logic gates, op-amps, flip-flops, etc. Many centres will have suitable ‘technology’ style kits available for these. Alternatively, the teacher or technician can easily make such modules on stripboard (Some are detailed at http://www.ikes.freeserve.co.uk).
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 by looking at system diagrams, then builds digital systems using logic gates.
Discrete components are followed by timing systems and sequential logic, concluding with op-amps and amplifier circuits.
Scheme 2 starts with basic circuit principles and components, input and output devices. The use of these devices in systems is then considered with logic gates and Boolean algebra. Op-amp and amplifier circuits are followed by capacitors and timing circuits, concluding with sequential logic.
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<th>week no</th>
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| 1       | System synthesis | • recognise and understand that simple systems consist of an input, a process, an output and possibly feedback;  
• analyse and design system diagrams where the lines between subsystems represent the flow of information;  
• represent complex systems in terms of subsystems;  
• recognise that signals may be analogue or digital in nature, and differentiate between them;  
• describe and explain the operation of modern electronic systems which may make use of several sensors. | draw block diagrams of simple systems  
use electronics kits to do ‘tasks’ |
| 2       | Logic gates and Boolean algebra | • identify and use NOT, AND, OR, NAND, NOR and EX-OR gates in circuits;  
• construct, recognise and use truth tables for NOT, AND, OR, NAND, NOR and EX-OR gates and simple combinations of them;  
• understand the operation of, and use combinations of NOT, AND, OR, NAND, NOR and EX-OR gates to form other logic functions;  
• generate the Boolean expression from a truth table or logic diagram. | use logic gates to build simple systems, using ‘kits’ or protoboard  
draw truth tables to represent a problem and then build circuit using gates  
use CMOS 4000 series gates on protoboard, identifying power connections |
| 3       | Design and simplification of combinational logic systems | • design a logic system from a truth table, written description or Boolean algebra expression using combinations of gates;  
• simplify a logic system using either Boolean algebra or Karnaugh maps;  
• convert logic systems comprising mixed gates into either NOR or NAND gates only;  
• describe and explain the operation of combinational logic systems. | (truth tables follow from logic gates)  
Boolean algebra / Karnaugh mapping could be left until later |
| 4       | Diodes | • describe the use of light-emitting diodes (LEDs), silicon diodes and Zener diodes and carry out relevant calculations;  
• calculate the value of the series resistor for dc circuits;  
• sketch $I - V$ characteristics for silicon diodes and Zener diodes; | use catalogues and data sheets  
use power supplies and meters  
plot simple characteristics |
| 5       | Diodes | • select appropriate silicon diodes and Zener diodes from given data sheets;  
• describe how a Zener diode can be used with a current limiting resistor to form a simple regulated voltage supply;  
• calculate the value and power rating of a suitable current limiting resistor. | make a Zener stabilised supply |
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| 6      | Voltage (V), current (I), resistance (R), power (P) | • understand the need for identifying a zero volt point in a circuit;  
• define and apply the fact that resistance, R, is the ratio of the voltage across a conductor, V, to the current, I, flowing through it, \[ R = \frac{V}{I} \]  
• calculate the combined resistance of resistors connected in series using \[ R = R_1 + R_2 + \ldots \]  
• calculate the combined resistance of resistors connected in parallel using \[ \frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \ldots \]  
• select appropriate preferred values for resistors from the E24 series;  
• identify the value of resistors using the colour code and BS1852 code;  
• define and apply the fact that power dissipated in a component is the product of V, the voltage across a component in a circuit, and I, the current through that component;  
• apply the formula \[ VI, \] or \[ I^2R, \] or \[ V^2/R \] to calculate the power dissipation in a circuit or component. | unit prefixes: p, μ, m, k, M, etc.  
identify components  
plot V–I characteristic for a resistor, and resistors in series/parallel  
this section could be incorporated in teaching as required |
| 7      | Resistive input transducers | • interpret and use characteristic curves (which may use logarithmic scales) of resistive input transducers;  
• describe and explain the use of LDRs, negative temperature coefficient thermistors, variable resistors and switches in a voltage divider circuit to provide analogue signals;  
• calculate suitable values for series resistors for use with and for protection of LDRs and thermistors;  
• carry out calculations on voltage dividers consisting of resistors and resistive input transducers. | use logarithmic scales  
build temperature or light sensing circuits |
| 8      | Operation amplifiers (op-amps) | • recall the characteristics of an ideal op-amp and be aware how these may be different for a typical op-amp;  
• know, understand and use the difference between inverting and non-inverting inputs;  
• understand the power supply requirements and output voltage swing limitations of real op-amps leading to saturation;  
• describe, understand and explain the use of an op-amp in a comparator circuit. | introduce protoboard  
built a temperature or light operated switch, using an LED and series resistor as indicator |
| 9      | Transistors and MOSFETs | • describe the use of an npn junction transistor as a switch;  
• describe the use of an n-channel (enhancement mode) MOSFET as a switch;  
• compare the advantages and disadvantages of a MOSFET and a junction transistor when they are both used as switches. | build a touch operated switch  
using a MOSFET to light a filament lamp, e.g. 12V or 6V, 100mA |
|        | Output Devices | • describe the use of electromagnetic relays, solenoids, buzzers, motors, and seven-segment displays in a system and understand and explain circuit protection provided by a diode in parallel with a relay, solenoid or motor;  
• understand and use COM, NO and NC notation. | use an NPN transistor or MOSFET to switch a relay to operate a filament lamp from a transformer |
<p>| 10     | ELEC1 revision and practice exam | | |</p>
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| 11     | Capacitors       | • recall that a capacitor is capable of storing electrical charge and electrical energy;  
• recall that a capacitor will block a direct current but will allow the passage of an alternating current;  
• recall that the unit of capacitance is the farad and that practical capacitors are usually measured in pF, nF and µF;  
• calculate the combined capacitance of capacitors connected in series and parallel combinations;  
• select appropriate capacitors given data on maximum working voltage, polarisation and leakage current. | capacitors in series and parallel could be investigated later with a 555 astable           |
| 12     | dc RC networks   | • explain the meaning of and calculate the value of the time constant for RC circuits;  
• recall that after one time constant:  
  for a charging capacitor, \( V = 0.63V_S \);  
  for a discharging capacitor, \( V = 0.37V_S \);  
  where \( V_S \) is the supply voltage and \( V \) is the voltage across the capacitor;  
• recall that:  
  after \( 0.69RC \), \( V = 0.5V_S \);  
  after \( 5RC \) for a charging capacitor, \( V = V_S \);  
  after \( 5RC \) for a discharging capacitor, \( V = 0 \);  
• sketch graphs of voltage against time for a capacitor charging and discharging. | plot charging and discharging graphs for an RC circuit, either manually, with a large time constant, or using a data logger |
| 13, 14 | Timing subsystems| • recall that a monostable circuit has one stable output state and one unstable output state;  
• recognise, draw and use the circuit diagram of a monostable based on a 555 timer circuit;  
• describe the operation of a monostable based on a 555 timer;  
• calculate the time period of such a monostable using \( T = 1.1RC \);  
• recall that an astable circuit has no stable output states but continually changes;  
• recognise, draw and use the circuit diagram of an astable based on a 555 timer circuit;  
• describe the operation of an astable based on a 555 timer;  
• calculate the time, \( t_L \), that the output is low using \( t_L = 0.7RSC \);  
• calculate the time, \( t_H \), that the output is high using \( t_H = 0.7(R_A+R_B)C \);  
• calculate the output frequency using \( f = \frac{1.44}{(R_d+2R_S)C} \) | build a 555 circuit that will make an LED go out for 1s  
build 555 circuit to flash an LED at 1Hz, and drive a piezo sounder at 1kHz  
add a second astable to make an intermittent sound |
| 15     | Sequential logic subsystems | • recall the circuit diagram of a bistable latch based on NAND gates and describe its operation and function;  
• recall the symbol for a rising edge triggered D-type flip-flop and describe its operation and function;  
• recall that in a shift register information is passed along from one element to the next on each clock pulse;  
• recall how rising edge triggered D-type flip-flops can be used to form a shift register and describe its operation and applications. | build a shift register using D-types                                                          |
| 16     | Counter subsystems| • describe the use of feedback to make a rising edge triggered D-type flip-flop divide by 2;  
• design 4-bit up or down counters based on rising edge triggered D-type flip-flops, and draw timing diagrams for these counters;  
• design 4-bit modulo-N counters based on rising edge triggered D-type flip-flops, and draw timing diagrams for these counters;  
• convert a 4-bit binary number to decimal or hexadecimal notation;  
• describe the use of a BCD or hexadecimal decoder with a seven segment display. | build a \( +2 \) circuit with a square wave input. Look at input and output on oscilloscope  
buid a 4-bit binary down-counter and up-counter  
build a \( +10 \) counter;  
interface it to a 7-segment display using a 4511 |
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| 17      | The Operational Amplifier | • recall the properties of an ideal op-amp;  
          • recall that for a real op-amp, the product of voltage gain and bandwidth is a constant;  
          • recall that negative feedback is used to reduce the overall voltage gain of an op-amp amplifier subsystem. | |
| 18, 19  | Amplifier subsystems | • use the formula voltage gain $\frac{V_{\text{out}}}{V_{\text{in}}}$  
          • recall and use the definition of bandwidth of an amplifier as the frequency range over which the voltage gain is within 70% of the maximum;  
          • draw and recognise the inverting op-amp amplifier circuit and describe its applications;  
          • use the formula $\frac{V_{\text{out}}}{V_{\text{in}}} = -\frac{R_f}{R_1}$  
          • recall that the input resistance is equal to the value of the input resistor, and that the circuit has a virtual earth point;  
          • make an inverting amplifier with $R_f/R_1 = \text{e.g.} -10$; display ac input and output on an oscilloscope; measure how gain varies with frequency. | |
|         |       | • draw and recognise a summing op-amp amplifier circuit and describe its applications;  
          • use the formula $V_{\text{out}} = -R_f \left( \frac{V_1}{R_1} + \frac{V_2}{R_2} + \frac{V_3}{R_3} \right)$  
          • recall that the input resistance of each input is equal to the value of its input resistor, and that the circuit has a virtual earth point;  
          • make a summing amplifier to add two voltages | |
|         |       | • draw and recognise the single op-amp difference amplifier circuit and describe its applications;  
          • use the formula $V_{\text{out}} = (V_+ - V_-) \frac{R_f}{R_1}$  
          • recall that the input resistance of each input is different and comparatively low;  
          • make a non-inverting amplifier and display ac input and output on an oscilloscope | |
|         |       | • draw and recognise the non-inverting op-amp amplifier circuit and describe its applications;  
          • use the formula $\frac{V_{\text{out}}}{V_{\text{in}}} = 1 + \frac{R_f}{R_1}$  
          • recall that the input resistance is equal to that of the op-amp;  
          • draw and recognise the voltage follower op-amp amplifier circuit and describe its applications;  
          • recall that the voltage gain of a voltage follower is 1, but that the current and power gain can be very large;  
          • recall that the input resistance is equal to the resistance of the op-amp. | |
| 20-24   | ELEC3 | PROJECT – 20 hours of class time | must be completed and marks submitted by 15th May may be necessary to leave some topics until after project |
### Power amplifier subsystems

- Use the formula power gain = \( \frac{P_{\text{out}}}{P_{\text{in}}} \)
- Recall and use the definition of bandwidth of an amplifier as the frequency range over which the power gain is within 50% of the maximum.
- Draw and recognise the enhancement mode MOSFET (both n- and p-channel) source follower amplifier circuits and describe their applications.
- Estimate the power dissipated in a source follower and describe methods for removing the excess heat generated.
- Draw and recognise the push-pull amplifier circuit using p- and n-channel enhancement mode MOSFETs and describe its operation and applications.
- Describe the common types of distortion associated with push-pull amplifier subsystems (cross-over and saturation/clipping) and how they can be reduced.
- Describe the advantages of push-pull amplifier subsystems over single ended output subsystems.
- Estimate the maximum power output from a push-pull amplifier subsystem.

### Revision, past papers, practice exam, etc.

- Use a MOSFET in source follower mode using a voltage to control the brightness of 12V halogen lamp experiments on push-pull circuits, showing cross-over and clipping.

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### SCHEME OF WORK 2

#### Voltage (V), current (I), resistance (R), power (P)

- Understand the need for identifying a zero volt point in a circuit.
- Define and apply the fact that resistance, \( R \), is the ratio of the voltage across a conductor, V, to the current, I, flowing through it, \( R = \frac{V}{I} \).
- Calculate the combined resistance of resistors connected in series using \( R = R_1 + R_2 + \ldots \).
- Calculate the combined resistance of resistors connected in parallel using \( \frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \ldots \).
- Select appropriate preferred values for resistors from the E24 series.
- Identify the value of resistors using the colour code and BS1852 code.
- Define and apply the fact that power dissipated in a component is the product of \( V \), the voltage across a component in a circuit, and \( I \), the current through that component.
- Apply the formula \( V \cdot I \), or \( I^2 \cdot R \), or \( V^2 / R \) to calculate the power dissipation in a circuit or component.

### Revision, past papers, practice exam, etc.

- Unit prefixes: p, \( \mu \), m, k, M, etc.
- Identify components plot \( V-I \) characteristic for a resistor, and resistors in series/parallel this section could be incorporated in teaching as required.
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| 2      | Resistive input transducers               | • interpret and use characteristic curves (which may use logarithmic scales) of resistive input transducers;  
• describe and explain the use of LDRs, negative temperature coefficient thermistors, variable resistors and switches in a voltage divider circuit to provide analogue signals;  
• calculate suitable values for series resistors for use with and for protection of LDRs and thermistors;  
• carry out calculations on voltage dividers consisting of resistors and resistive input transducers. | use logarithmic scales  
build temperature or light sensing circuits                          |
| 3      | Diodes                                    | • describe the use of light-emitting diodes (LEDs), silicon diodes and Zener diodes and carry out relevant calculations;  
• calculate the value of the series resistor for dc circuits;  
• sketch $I-V$ characteristics for silicon diodes and Zener diodes; | use catalogues and data sheets  
use power supplies and meters  
plot simple characteristics                                              |
| 4      | Diodes                                    | • select appropriate silicon diodes and Zener diodes from given data sheets;  
• describe how a Zener diode can be used with a current limiting resistor to form a simple regulated voltage supply;  
• calculate the value and power rating of a suitable current limiting resistor. | make a Zener stabilised supply                                       |
| 5      | Transistors and MOSFETs                   | • describe the use of an npn junction transistor as a switch;  
• describe the use of an n-channel (enhancement mode) MOSFET as a switch;  
• compare the advantages and disadvantages of a MOSFET and a junction transistor when they are both used as switches. | build a touch operated switch using a MOSFET to light a filament lamp, e.g. 12V or 6V, 100mA |
|        | Output Devices                            | • describe the use of electromagnetic relays, solenoids, buzzers, motors, and seven-segment displays in a system and understand and explain circuit protection provided by a diode in parallel with a relay, solenoid or motor;  
• understand and use COM, NO and NC notation.                               | use an NPN transistor or MOSFET to switch a relay to operate a filament lamp from a transformer |
| 6      | Operation amplifiers (op-amps)            | • recall the characteristics of an ideal op-amp and be aware how these may be different for a typical op-amp;  
• know, understand and use the difference between inverting and non-inverting inputs;  
• understand the power supply requirements and output voltage swing limitations of real op-amps leading to saturation;  
• describe, understand and explain the use of an op-amp in a comparator circuit. | introduce  
protoboard  
build a temperature or light operated switch, using an LED and series  
resistor as indicator                                                      |
| 7      | System synthesis                          | • recognise and understand that simple systems consist of an input, a process, an output and possibly feedback;  
• analyse and design system diagrams where the lines between subsystems represent the flow of information;  
• represent complex systems in terms of subsystems;  
• recognise that signals may be analogue or digital in nature, and differentiate between them;  
• describe and explain the operation of modern electronic systems which may make use of several sensors. | draw block diagrams of simple systems  
use electronics kits to do ‘tasks’                                         |
| 8      | Design and simplification of combinational logic systems | • design a logic system from a truth table, written description or Boolean algebra expression using combinations of gates;  
• simplify a logic system using either Boolean algebra or Karnaugh maps;  
• convert logic systems comprising mixed gates into either NOR or NAND gates only;  
• describe and explain the operation of combinational logic systems. | (truth tables follow from logic gates)  
Boolean algebra / Karnaugh mapping could be left until later                  |
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<td>9</td>
<td>Logic gates and Boolean algebra</td>
<td>• identify and use NOT, AND, OR, NAND, NOR and EX-OR gates in circuits;</td>
<td>use logic gates to build simple systems, using 'kits' or protoboard</td>
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<td>• construct, recognise and use truth tables for NOT, AND, OR, NAND, NOR</td>
<td>draw truth tables to represent a problem and then build circuit using</td>
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<td></td>
<td></td>
<td>and simple combinations of them;</td>
<td>gates</td>
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<td>• understand the operation of, and use combinations of NOT, AND, OR, NAND,</td>
<td>use CMOS 4000 series gates on protoboard, identifying power connections</td>
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<td>NOR and EX-OR gates to form other logic functions;</td>
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<td>• generate the Boolean expression from a truth table or logic diagram.</td>
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<td>10</td>
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<td>use logic gates to build simple systems, using 'kits' or protoboard</td>
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<td>ELEC1 revision and practice exam</td>
<td>draw truth tables to represent a problem and then build circuit using</td>
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<td>11</td>
<td>The Operational Amplifier</td>
<td>• recall the properties of an ideal op-amp;</td>
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<td>• recall that for a real op-amp, the product of voltage gain and</td>
<td>make an inverting amplifier with ( \frac{R_f}{R_1} ) = e.g. –10;</td>
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<td></td>
<td>bandwidth is a constant;</td>
<td>display ac input and output on an oscilloscope; measure how gain</td>
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<td>• recall that negative feedback is used to reduce the overall voltage</td>
<td>varies with frequency.</td>
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<td>gain of an op-amp amplifier subsystem.</td>
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<td>12, 13</td>
<td>Amplifier subsystems</td>
<td>• use the formula voltage gain = ( \frac{V_{out}}{V_{in}} )</td>
<td>make a summing amplifier to add two voltages</td>
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<td>• recall and use the definition of bandwidth of an amplifier as the</td>
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<td>frequency range over which the voltage gain is within 70% of the</td>
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<td>maximum;</td>
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<td>• draw and recognise the inverting op-amp amplifier circuit and</td>
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<td>describe its applications;</td>
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<td>• use the formula ( \frac{V_{out}}{V_{in}} = -\frac{R_f}{R_1} )</td>
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<td>• recall that the input resistance is equal to the value of the input</td>
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<td>resistor, and that the circuit has a virtual earth point;</td>
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<td>make a summing amplifier to add two voltages</td>
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<td>its applications;</td>
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<td>• use the formula ( V_{out} = -R_f \left( \frac{V_1}{R_1} + \frac{V_2}{R_2} + \frac{V_3}{R_3} \right) )</td>
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<td>• recall that the input resistance of each input is equal to the value</td>
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<td>of its input resistor, and that the circuit has a virtual earth point;</td>
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<td>make a summing amplifier to add two voltages</td>
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<td>• draw and recognise the single op-amp difference amplifier circuit</td>
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<td>and describe its applications;</td>
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<td>• use the formula ( V_{out} = (V_+ - V_-) \frac{R_f}{R_1} )</td>
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<td>• recall that the input resistance of each input is different and</td>
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<td>comparatively low;</td>
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| 12, 13 cont. | | • draw and recognise the non-inverting op-amp amplifier circuit and describe its applications;  
  • use the formula \( V_{\text{out}} = V_{\text{in}} + R_f/R_1 \);  
  • recall that the input resistance is equal to that of the op-amp;  
  • draw and recognise the voltage follower op-amp amplifier circuit and describe its applications;  
  • recall that the voltage gain of a voltage follower is 1, but that the current and power gain can be very large;  
  • recall that the input resistance is equal to the resistance of the op-amp. | make a non-inverting amplifier and display ac input and output on an oscilloscope |
| 14, 15 | Power amplifier subsystems | • use the formula power gain = \( \frac{P_{\text{out}}}{P_{\text{in}}} \);  
  • recall and use the definition of bandwidth of an amplifier as the frequency range over which the power gain is within 50% of the maximum;  
  • draw and recognise the enhancement mode MOSFET (both n- and p-channel) source follower amplifier circuits and describe their applications;  
  • estimate the power dissipated in a source follower and describe methods for removing the excess heat generated;  
  • draw and recognise the push-pull amplifier circuit using p- and n-channel enhancement mode MOSFETs and describe its operation and applications;  
  • describe the common types of distortion associated with push-pull amplifier subsystems (cross-over and saturation/clipping) and how they can be reduced;  
  • describe the advantages of push-pull amplifier subsystems over single ended output subsystems;  
  • estimate the maximum power output from a push-pull amplifier subsystem. | use a MOSFET in source follower mode using a voltage to control the brightness of 12V halogen lamp experiments on push-pull circuits, showing cross-over and clipping |
| 16 | Capacitors | • recall that a capacitor is capable of storing electrical charge and electrical energy;  
  • recall that a capacitor will block a direct current but will allow the passage of an alternating current;  
  • recall that the unit of capacitance is the farad and that practical capacitors are usually measured in pF, nF and µF;  
  • calculate the combined capacitance of capacitors connected in series and parallel combinations;  
  • select appropriate capacitors given data on maximum working voltage, polarisation and leakage current. | capacitors in series and parallel could be investigated later with a 555 astable |
| 17 | dc RC networks | • explain the meaning of and calculate the value of the time constant for RC circuits;  
  • recall that after one time constant:  
    - for a charging capacitor, \( V = 0.63V_S \);  
    - for a discharging capacitor, \( V = 0.37V_S \);  
    - where \( V_S \) is the supply voltage and \( V \) is the voltage across the capacitor;  
  • recall that:  
    - after 0.69RC, \( V = 0.5V_S \);  
    - after 5RC for a charging capacitor, \( V = V_S \);  
    - after 5RC for a discharging capacitor, \( V = 0 \);  
  • sketch graphs of voltage against time for a capacitor charging and discharging. | plot charging and discharging graphs for an RC circuit, either manually, with a large time constant, or using a data logger |
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| 18, 19 | Timing subsystems      | • recall that a monostable circuit has one stable output state and one unstable output state;  
• recognise, draw and use the circuit diagram of a monostable based on a 555 timer circuit;  
• describe the operation of a monostable based on a 555 timer;  
• calculate the time period of such a monostable using \( T = 1.1RC \);  
• recall that an astable circuit has no stable output states but continually changes;  
• recognise, draw and use the circuit diagram of an astable based on a 555 timer circuit;  
• describe the operation of an astable based on a 555 timer;  
• calculate the time, \( t_L \), that the output is low using \( t_L = 0.7R_FB C \);  
• calculate the time, \( t_H \), that the output is high using \( t_H = 0.7(R_A + R_B)C \);  
• calculate the output frequency using \( f = \frac{1.44}{(R_d + 2R_B)C} \). | build a 555 circuit that will make an LED go out for 1s.  
built 555 circuit to flash an LED at 1Hz, and drive a piezo sounder at 1kHz.  
add a second astable to make an intermittent sound. |
| 20-24  | ELEC3                  | PROJECT – 20 hours of class time                                                                                                                                                                                                                                                                                                       | must be completed and marks submitted by 15th May.  
may be necessary to leave some topics until after project. |
| 25     | Sequential logic subsystems | • recall the circuit diagram of a bistable latch based on NAND gates and describe its operation and function;  
• recall the symbol for a rising edge triggered D-type flip-flop and describe its operation and function;  
• recall that in a shift register information is passed along from one element to the next on each clock pulse;  
• recall how rising edge triggered D-type flip-flops can be used to form a shift register and describe its operation and applications. | build a shift register using D-types. |
| 26     | Counter subsystems     | • describe the use of feedback to make a rising edge triggered D-type flip-flop divide by 2;  
• design 4-bit up or down counters based on rising edge triggered D-type flip-flops, and draw timing diagrams for these counters;  
• design 4-bit modulo-N counters based on rising edge triggered D-type flip-flops, and draw timing diagrams for these counters;  
• convert a 4-bit binary number to decimal or hexadecimal notation;  
• describe the use of a BCD or hexadecimal decoder with a seven segment display. | build a +2 circuit with a square wave input.  
Look at input and output on oscilloscope.  
build a 4-bit binary down-counter and up-counter.  
build a +10 counter; interface it to a 7-segment display using a 4511. |
| 27-30  | Revision, past papers, practice exam, etc. |                                                                                                                                                                                                                                                                                                                                         |                                                                                                                                              |