Department
for Education

Electronics

GCSE Subject Content

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Contents

The content for GCSE electronics

Introduction

1. The GCSE subject content sets out the knowledge, understanding and skills for GCSE specifications in electronics, to ensure progression from key stage 3 national curriculum science and mathematics requirements and the possibility of development into A level. They provide the framework within which awarding organisations create the detail of the subject specifications.

Aims and objectives

2. Specifications in GCSE electronics will ensure that students have the scientific and mathematical knowledge and understanding and engineering skills to tackle problems in an electronics context. GCSE electronics should be studied in such a way as to develop and maintain their interest in engineering subjects and the appreciation of their relevance to their everyday lives. The scope and nature of such study should be coherent and practical.

3. GCSE specifications in electronics should enable students to:

- develop scientific knowledge and conceptual understanding of the behaviour of analogue and digital electrical / electronic circuits including a wide range of electronic components
- develop an understanding of the nature, processes and methods of electronics as an engineering discipline to help them answer questions about practical circuits
- be aware of new and emerging technologies
- develop practical, problem-solving and evaluative skills in the identification of needs in the world around them and to propose and test electronic solutions
- progress to level 3 qualifications in electronics and engineering

Subject content

4. Specifications for GCSE electronics should reflect the aims and outcomes outlined above and should require students to develop the electronic engineering skills, knowledge and understanding set out below, giving due consideration to the assessment objectives. The essential subject content outlined here provides the framework for developing a coherent study at GCSE.

5. Specifications must require students to develop the mathematical knowledge understanding and skills included under each topic and listed in Appendix 3. Appendices 1 and 2 also form part of the mandatory content requirement.

6. This content sets out the full range of content for GCSE specifications in electronics.

7. Awarding organisations may, however, use any flexibility to increase depth, breadth or context within the specified topics, as long as the rigour and challenge of the specification is maintained.

Knowledge and understanding

8. GCSE specifications in electronics should require students to demonstrate and apply knowledge and understanding of:

Scientific communication

- the use of scientific vocabulary, symbols, terminology and definitions

Basic circuits

- electronic systems and sub-systems
    - the way in which electronic systems are assembled from sensing, processing and output sub-systems
    - the principles of a range of sensing, processing and output sub-systems
    - the need for and use of transducer drivers
- circuit concepts
    - the communication of electrical circuits using standard circuit symbols connected in standard ways
    - the analysis of circuits in terms of voltage, current, resistance, energy and power
    - connecting and making measurements to test electrical components and circuits, using multimeters (on voltage, current and resistance ranges), timing equipment, logic probes and oscilloscopes (or computers configured as oscilloscopes), including investigating current-voltage characteristics
- resistive components in circuits
    - the qualitative and quantitative effects of resistors and resistor combinations (series and parallel) in circuits

- the design and testing of sensing circuits using resistors and a range of passive sensors, including light, temperature, pressure, moisture, switch, sound and pulse generator
- the selection of resistors for circuits, considering resistance, tolerance and power dissipation

- switching circuits

  - the analysis and comparison of the action of switching circuits based upon npn transistors, MOSFETs and voltage comparator ICs
  - calculations on switching circuits based upon npn transistors
  - the use of data to design switching circuits using npn transistors and comparators

- applications of diodes

  - the current-voltage behaviour and uses of silicon diodes for component protection in DC circuits and half-wave rectification AC circuits
  - the use of zener diodes in voltage regulation circuits

- uses of mathematics

  - the application of the equations relating pd, current, resistance, power, energy and time and solve problems for circuits which include resistors in series, resistors in parallel and resistors in sensing and transistor circuits

$$R = \frac{V}{I};\ P = VI = I^2R = \frac{V^2}{R};\ E = Pt;$$

$$R = R_1 + R_2;\ R = \frac{R_1R_2}{R_1 + R_2};\ I_C = h_{FE}I_B;\ V_{OUT} = \frac{R_2}{R_1 + R_2}V_{IN}$$

  - calculate expected voltage values in order to test circuits
  - plotting and interpreting I-V characteristic graphs and switching graphs

Digital circuits

- combinational logic systems

  - the meaning of a logic level
  - the identification and behaviour of logic gates: NOT and 2-input AND, OR, NAND and NOR, singly and in combination
  - the use of truth tables and basic Boolean manipulation for systems of gates

- the design of processing systems consisting of logic gates to solve problems, incorporating pull-up and pull-down resistors to provide the correct logic level

- timing circuits
  - the variation with time of the voltage across a charging or discharging capacitor in an RC circuit and the effect on the voltage-time graph of varying the values of R and/or C
  - the use of an RC network to produce a time delay
  - the characterisation of monostable time-delay and astable circuits
  - the configuration of a 555-timer as a monostable or an astable, including relevant calculations
  - the use of an oscilloscope (or a computer configured as an oscilloscope) to determine the properties of time delay and astable circuits

- sequential systems
  - the action of rising-edge-triggered D-type flip-flops and latches (registers), BCD and decade counters
  - the use of timing diagrams for flip-flops, BCD counters and decade counters
  - the construction of 1- and 2-bit binary up-counters from D-type flip-flops
  - the design and analysis of systems using counters and combinational logic to produce a given sequence

- uses of mathematics
  - logic simplification using $\overline{A+B} = \overline{A}.\overline{B}$; $\overline{A.B} = \overline{A}+\overline{B}$
  - the interpretation of decay graphs for RC networks, V-t graphs for monostables and astables and timing graphs for counters
  - the calculation of the time delay of a monostable and frequency, period, mark-space ratio for an astable

$$T = 1.1RC \,;\; f = \frac{1}{T} = \frac{1.44}{(R_1 + 2R_2)C} \,;\; \frac{T_{\mathrm{ON}}}{T_{\mathrm{OFF}}} = \frac{R_1 + R_2}{R_2}$$

Interfacing digital to analogue circuits

- interface circuits
  - the action of a Schmitt inverter and how it can be used in debouncing mechanical switches and analogue sensors
  - the comparison of the properties of transistors, comparators and Schmitt inverters as interfaces between analogue and digital systems

- the design of transistor switching circuits to interface input sensors to outputs

Analogue communications

- operational amplifiers (op-amps)

  - the voltage gain and bandwidth of an amplifier and the trade-off between them
  - circuits for non-inverting and inverting op-amp amplifier circuits and use of the gain formulae in calculations
  - the effect of clipping distortion on the output signal of an amplifier
  - circuits for mixers based on a summing op-amp circuit and calculations of the output voltage

- uses of mathematics

  - calculations involving the gain of amplifiers:

$$G = \frac{V_{\mathrm{OUT}}}{V_{\mathrm{IN}}};\ G = 1 + \frac{R_{\mathrm{F}}}{R_1};\ G = -\frac{R_{\mathrm{F}}}{R_{\mathrm{IN}}};\ V_{\mathrm{OUT}} = -R_{\mathrm{F}}\left(\frac{V_1}{R_1} + \frac{V_2}{R_2} + \ldots\right)$$

  - the use of V-f graphs to determine bandwidth; V-t graphs to illustrate clipping distortion; calculations from V_{IN}-V_{OUT} graphs

Control circuits

- microcontrollers

  - the nature of a microcontroller as a programmable integrated circuit into which software can be loaded to carry out a range of different tasks
  - interfacing microcontrollers with sensing circuits and output devices
  - the design of flowchart programs to enable microcontrollers to perform tasks
  - why microcontrollers have been recently adopted as standard technology in the vehicle and domestic appliance industry

Skills

9. Specifications for GCSE electronics should require students, in the context of the knowledge and understanding specified above, to demonstrate the ability to:

Think like an electronic engineer

- analyse a context to enable solutions to a design opportunity to be developed
- make predictions about the way that electronic systems behave
- evaluate practical risks in system development and application

Investigate

- make and record measurements on electrical circuits
- plan tests selecting appropriate techniques and instruments
- carry out tests having due regard to the correct manipulation of apparatus, accuracy of measurement and Health and Safety considerations
- report results using standard scientific conventions

Create, test and evaluate

- develop a design brief to tackle a design opportunity or solve a problem
- propose an electronic system, composed of sub-systems, to satisfy the design brief
- design, build and test the electronic system, composed of sub-systems, evaluating its performance against the design brief, modifying as appropriate
- suggest improvements to the electronic system following evaluation

Assessment of electronics skills

10. Specifications of GCSE electronics should assess all these electronics skills by requiring students to undertake a single extended system design and construction task. The nature of which will require for its solution a synthesis of different aspects of the knowledge and understanding specified above.

11. For a given context having an electronic design potential solution or identifiable problem, students will be required to:

- investigate the context
- develop a design brief to develop an electronic system, based on sub-systems, to tackle it
- design, create and test sub-systems and the whole system against the design brief
- evaluate and report on the solution

Appendix 1

Equations in electronics

(a) In solving quantitative problems, students should be able correctly to recall and apply the following relationships using standard SI units:

potential difference = current × resistance	$V = IR$
power = potential difference × current	$P = VI$
power = (current)^2 × resistance	$P = I^2R$
energy transfer = power × time	$E = Pt$

$R = R_1 + R_2$	resistors in series
$R = \dfrac{R_1 R_2}{R_1 + R_2}$	resistors in parallel

(b) In addition, students should be able correctly to select from a list and apply the following relationships

$V_{\text{OUT}} = \dfrac{R_2}{R_1 + R_2} V_{\text{IN}}$	potential divider
$P = \dfrac{V^2}{R}$	power dissipated in a resistor
$I_{\text{C}} = h_{\text{FE}} I_{\text{B}}$	current gain of a junction transistor
$f = \dfrac{1}{T}$	frequency, period relationship
$T = 1.1RC$	time delay of a monostable
$f = \dfrac{1.44}{(R_1 + 2R_2)C}$	frequency of an astable
$\dfrac{T_{\text{ON}}}{T_{\text{OFF}}} = \dfrac{R_1 + R_2}{R_2}$	mark/space ratio of an astable
$G = \dfrac{V_{\text{OUT}}}{V_{\text{IN}}}$	amplifier voltage gain
$G = 1 + \dfrac{R_{\text{F}}}{R_1}$	non-inverting op-amp circuit voltage gain
$G = -\dfrac{R_{\text{F}}}{R_{\text{IN}}}$	inverting op-amp circuit voltage gain
$V_{\text{OUT}} = -R_{\text{F}}\left(\dfrac{V_1}{R_1} + \dfrac{V_2}{R_2} + ...\right)$	summing amplifier output voltage
$\overline{A + B} = \overline{A}.\overline{B}$ and $\overline{A.B} = \overline{A} + \overline{B}$	Boolean indentities

Appendix 2

SI units

Students should recognise, carry out calculations and be able to communicate using:

(a) The following SI units:

ampere (A), second (s), hertz (Hz), joule (J), watt (W), volt (V), ohm (Ω);

(b) The following SI multipliers:

p, n, μ, m, k, M, G, T.

Appendix 3

Mathematical skills required for GCSE electronics

Arithmetic and numerical computation

- Recognise and use expressions in decimal form
- Recognise and use expressions in standard form
- Use ratios, fractions and percentages
- Calculate squares and square roots

Handling data

- Use an appropriate number of significant figures
- Find arithmetic means
- Make order of magnitude calculations

Algebra

- Understand and use the symbols =, <, <<, >>, >, ∝, ~
- Change the subject of an equation
- Substitute numerical values into algebraic equations using appropriate units for physical quantities
- Solve simple algebraic equations
- Use simple Boolean identities

Graphs

- Translate information between graphical and numeric form
- Plot two variables from experimental or other data
- Draw an appropriate trend line onto plotted data
- Interpret data presented in graphical form
- Determine the slope of a graph
- Calculate the rate of change from a graph showing a linear relationship
- Draw and use the slope of a tangent to a curve as a measure of rate of change

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