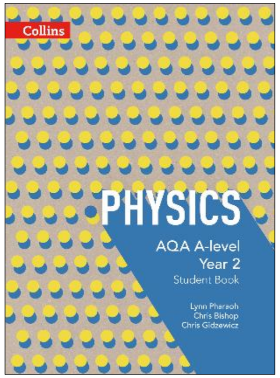
AQA A-level Physics Year 2

Scheme of Work – Optional Units



Scheme of Work
AQA A-level Physics Year 2 of A-level

This course covers the requirements of the second year of AQA AS and A-level Physics specification. These schemes of work are designed to accompany the use of Collins' AQA A-level Physics Year 2 Student Book.

We have assumed that 120 one-hour lessons are taught during the year, 95 of which will cover the Specification's Core units. Each lesson is matched to the Specification content. It is suggested in which lessons the six Required Practicals may be carried out.

Outline schemes have been provided for each of the five Option units, allowing 25 lessons for each.

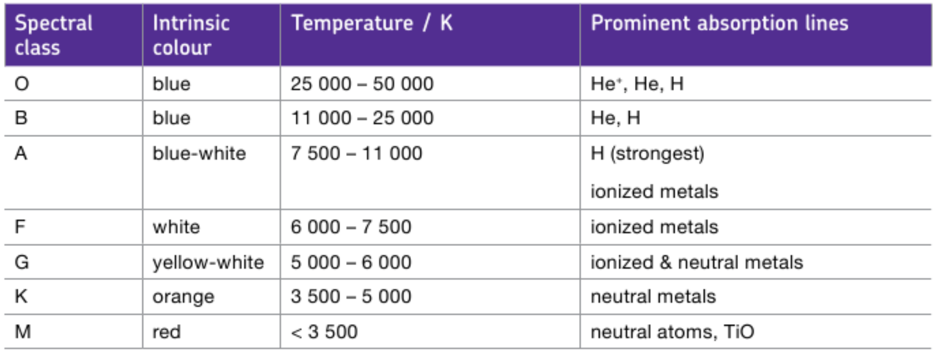
The schemes of work suggested are of course flexible, and editable, to correspond with your timetabling and to enable you to plan your own route through the course. Time is allowed in the schemes for consolidation and exam questions practice at the end of each topic. This should help enable students to draw together all their knowledge from earlier in the course.

Scheme of Work
AQA A-level Physics Year 2 of A-level

Option Unit: Astrophysics (25 hours)

One-hour lessons	Specification Content
CHAPTER 11 TELESCOPES (6 hours)	
1	3.9.1.1 Astronomical telescope consisting of two converging lenses Ray diagram to show the image formation in normal adjustment Focal lengths of the lenses Angular magnification in normal adjustment $M = \frac{\text{angle subtended by image at eye}}{\text{angle subtended by object at unaided eye}}$ $M = \frac{f_o}{f_e}$
2	3.9.1.2 Qualitative treatment of spherical and chromatic aberration 3.9.1.2 Reflecting telescopes Cassegrain arrangement using a parabolic concave primary mirror and convex secondary mirror Ray diagram to show path of rays through telescope up to the eyepiece Relative merits of reflectors and refractors
3	3.9.1.4 Minimum angular resolution of telescope Rayleigh criterion, $\theta \approx \lambda/D$ Students should be familiar with the rad as the unit of angle Collecting power is proportional to diameter^2
4	3.9.1.3 Single dish radio telescopes, I-R, U-V and X-rays telescopes Similarities and differences of radio telescopes compared to optical telescopes Discussion should include structure, positioning and use, together with comparisons of resolving and collecting powers
5	3.9.1.4 Comparison of the eye and CCD as detectors in terms of quantum efficiency, resolution, and convenience of use No knowledge of the structure of the CCD is required
6	*(Consolidation and exam questions practice)*

One-hour lessons	Specification Content
CHAPTER 12 CLASSIFICATION OF STARS (6 hours)	
1	3.9.2.1 Classification by luminosity Apparent magnitude, *m* The Hipparchus scale Dimmest visible stars have a magnitude of 6
2	3.9.2.3 Inverse square law, assumptions in its application 3.9.2.1 Relation between brightness and apparent magnitude. Difference of 1 on magnitude scale is equal to an intensity ratio of 2.51 Brightness is a subjective scale of measurement *(Maths review of manipulation of logarithms)*
3	3.9.2.2 Absolute magnitude, *M* Parsec and light year Definition of *M*, relation to *m*: $m - M = 5 \log \frac{d}{10}$
4	3.9.2.3 Classification by temperature, black-body radiation Stefan's law $P = \sigma A T^4$ and Wien's displacement law $\lambda_{max} T$ = constant = 2.9×10^{-3} m K General shape of black-body curves, use of Wien’s displacement law to estimate black-body temperature of sources Experimental verification is not required Assumption that a star is a black body Use of Stefan's law to compare the power output, temperature and size of stars
5	3.9.2.4 Principle of the use of stellar spectral classes Description of the main classes:

<table>
<tr><th>One-hour lessons</th><th>Specification Content</th></tr>
<tr><td></td><td>

<table>
<tr><th>Spectral class</th><th>Intrinsic colour</th><th>Temperature / K</th><th>Prominent absorption lines</th></tr>
<tr><td>O</td><td>blue</td><td>25 000 – 50 000</td><td>He$^+$, He, H</td></tr>
<tr><td>B</td><td>blue</td><td>11 000 – 25 000</td><td>He, H</td></tr>
<tr><td>A</td><td>blue-white</td><td>7 500 – 11 000</td><td>H (strongest)
ionized metals</td></tr>
<tr><td>F</td><td>white</td><td>6 000 – 7 500</td><td>ionized metals</td></tr>
<tr><td>G</td><td>yellow-white</td><td>5 000 – 6 000</td><td>ionized & neutral metals</td></tr>
<tr><td>K</td><td>orange</td><td>3 500 – 5 000</td><td>neutral metals</td></tr>
<tr><td>M</td><td>red</td><td>< 3 500</td><td>neutral atoms, TiO</td></tr>
</table>
Temperature related to absorption spectra limited to hydrogen Balmer absorption lines: requirement for atoms in an $n = 2$ state</td></tr>
<tr><td>6</td><td><i>(Consolidation and exam questions practice)</i></td></tr>
<tr><td colspan="2">CHAPTER 13 STELLAR EVOLUTION (6 hours)</td></tr>
<tr><td>1</td><td>3.9.2.5 The Hertzsprung-Russell (HR) diagram
Stellar evolution <i>(general overview from protostar to stable main sequence star)</i>
General shape (of HR diagram): main sequence, dwarfs and giants</td></tr>
<tr><td>2</td><td>Axis scales range from –10 to +15 (absolute magnitude) and 50 000 K to 2500 K (temperature)or OBAFGKM (spectral class)
Students should be familiar with the position of the Sun on the HR diagram
Stellar evolution: path of a star similar to our Sun on the HR diagram from (main sequence) to white dwarf</td></tr>
<tr><td>3</td><td>3.9.2.6 Supernovae, neutron stars and black holes
Defining properties: rapid increase in absolute magnitude of supernovae; composition and density of neutron stars</td></tr>
<tr><td>4</td><td>3.9.2.6 Escape velocity > c for black holes
Calculation of the radius of the event horizon for a black hole, Schwarzschild radius, $R_s \approx 2GM/c^2$
Gamma ray bursts due to the collapse of supergiant stars to form neutron stars or black holes
Comparison of energy output with total energy output of the Sun
Supermassive black holes at the centre of galaxies</td></tr>
<tr><td>5</td><td>3.9.2.6 Use of type 1a supernovae as standard candles to determine distances
Students should be familiar with the light curve of typical type 1a supernovae
Controversy concerning accelerating Universe and dark energy <i>(introduction)</i></td></tr>
<tr><td>6</td><td><i>(Consolidation and exam questions practice)</i></td></tr>
<tr><td colspan="2">CHAPTER 14 COSMOLOGY (7 hours)</td></tr>
<tr><td>1</td><td>3.9.3.1 Doppler effect</td></tr>
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One-hour lessons	Specification Content
	$\Delta f/f = v/c$ $z = \Delta\lambda/\lambda = -v/c$ for $v \ll c$ applied to optical and radio frequencies
2	3.9.3.1 Calculations on binary stars viewed in the plane of orbit Galaxies and quasars
3	3.9.3.2 Hubble's law Recession velocity $v = Hd$ Simple interpretation as expansion of universe; estimation of age of universe, assuming H is constant Qualitative treatment of Big Bang theory 3.9.2.6 Controversy concerning accelerating Universe and dark energy
4	3.9.3.2 Qualitative treatment of Big Bang theory including evidence from cosmological microwave background radiation, and relative abundance of hydrogen and helium
5	3.9.3.3 Quasars Quasars as the most distant measurable objects Discovery of quasars as bright radio sources Quasars show large optical red shifts; estimation involving distance and power output Formation of quasars from active supermassive black holes
6	3.9.3.4 Detection of exoplanets Difficulties in the direct detection of exoplanets Detection techniques will be limited to variation in Doppler shift (radial velocity method) and the transit method Typical light curve
7	*(Consolidation and exam questions practice)*

Option Unit: Medical Physics (25 hours)

One-hour lessons	Specification Content
CHAPTER 15 PHYSICS OF THE EYE AND THE EAR (9 hours)	
1	3.10.1.1 Physics of vision The eye as an optical refracting system Sensitivity of the eye; spectral response as a photodetector Spatial resolution of the eye; explanation in terms of the behaviour of rods and cones
2	3.10.1.2 Defects of vision and their correction using lenses Properties of converging and diverging lenses; principal focus, focal length and power $\text{power} = \frac{1}{f}$ $\frac{1}{u} + \frac{1}{v} = \frac{1}{f}$ $m = \frac{v}{u}$ 3.10.1.1 The eye as an optical refracting system, including ray diagrams of image formation
4	3.10.1.2 Myopia, hypermetropia, astigmatism Ray diagrams and calculations of powers (in dioptres) of correcting lenses for myopia and hypermetropia The format of prescriptions for astigmatism *(Consolidation and exam questions practice)*
5	
6	3.10.2.1 Ear as a sound detection system Simple structure of the ear, transmission processes
7	3.10.2.2 Sensitivity and frequency response Definition of intensity Human perception of relative intensity levels and the need for a logarithmic scale to reflect this *(Review of properties of logarithms)* Intensity level = 10 log (I/I_0) where the threshold of hearing $I_0 = 1.0 \times 10^{-12}$ W m^{-2} Measurement of sound intensity levels and the use of dB scale; relative intensity levels of sounds
8	3.10.2.2 Production and interpretation of equal loudness curves Measurement of sound intensity levels and the use of dBA scale
9	3.10.2.3 Defects of hearing The effect on equal loudness curves and the changes experienced in terms of hearing loss due to injury resulting from exposure to excessive noise or deterioration with age (excluding physiological changes)

One-hour lessons	Specification Content
	(Consolidation and exam questions practice)
CHAPTER 16 BIOLOGICAL MEASUREMENTS (2 hours)	
1	3.10.3.1 Simple ECG machines and the normal ECG waveform Principles of operation for obtaining the ECG waveform; explanation of the characteristic shape of a normal ECG waveform
2	*(Consolidation and exam questions practice)*
CHAPTER 17 NON-IONISING IMAGING (5 hours)	
1	3.10.4.1 Ultrasound imaging Piezoelectric devices Principles of generation and detection of ultrasound pulses Reflection and transmission characteristics of sound waves at tissue boundaries, acoustic impedance, Z, and attenuation Use of the equations $Z = \rho c$ and $\frac{I_r}{I_i} = \left(\frac{Z_2 - Z_1}{Z_2 + Z_1}\right)^2$
2	3.10.4.1 A-scans and B-scans Examples of applications Advantages and disadvantages of ultrasound imaging in comparison with alternatives including safety issues and resolution
3	3.10.4.2 Fibre optics and endoscopy *(Review of total internal reflection and optical fibres)* Properties of fibre optics and applications in medical physics; including total internal reflection at the core–cladding interface Physical principles of the optical system of a flexible endoscope; the use of coherent and non-coherent fibre bundles; examples of use for internal imaging and related advantages
4	3.10.4.3 Magnetic resonance (MR) scanner Basic principles of MR scanner including: - cross-section of patient scanned using magnetic fields - protons initially aligned with spins parallel - spinning hydrogen nuclei (protons) precess about the magnetic field lines of a superconducting magnet - ‘gradient’ field coils used to scan cross-section - short radio frequency (RF) pulses cause excitation and change of spin state in successive small regions - protons excited during the scan emit RF signals as they de-excite - RF signals detected and the resulting signals are processed by a computer to produce a visual image Students will not be asked about the production of magnetic fields used in an MR scanner, or about de-excitation relaxation times

One-hour lessons	Specification Content
5	*(Consolidation and exam questions practice)*
CHAPTER 18 X-RAY IMAGING (4 hours)	
1	3.10.5.1 The physics of diagnostic X-rays Physical principle of the production of X-rays; maximum photon energy, energy spectrum; continuous spectrum and characteristic spectrum Rotating-anode X-ray tube; methods of controlling the beam intensity, the photon energy, the image sharpness and contrast, and the patient dose
2	3.10.5.2 Image detection and enhancement Flat panel (FTP) detectors including X-ray scintillator, photodiode pixels, electronic scanning Advantages of FTP detector compared with photographic detection 3.10.5.2 Contrast enhancement; use of X-ray opaque material as illustrated by the barium meal technique Photographic detection with intensifying screen and fluoroscopic image intensification; reasons for using these
3	3.10.5.3 Absorption of X-rays Exponential attenuation *(Review of exponentials and logarithms)* Linear coefficient μ, mass attenuation coefficient μ_m, half-value thickness $I = I_0 e^{-\mu x}$ $\mu_m = \mu/\rho$ Differential tissue absorption of X-rays excluding details of the absorption process
4	3.10.5.4 CT scanner Basic principles of CT scanner: - movement of X-ray tube - narrow, monochromatic X-ray beam - array of detectors - computer used to process the signals and produce a visual image *(Comparison of imaging techniques)* Comparisons will be limited to advantages and disadvantages of image resolution, cost and safety issues Students will not be asked about the construction or operation of the detectors *(Consolidation and exam questions practice)*
CHAPTER 19 RADIONUCLIDE IMAGING AND THERAPY (5 hours)	
1	3.10.6.2 Half-life *(Review of radioactive decay)* Physical, biological and effective half-lives: $\frac{1}{T_E} = \frac{1}{T_B} + \frac{1}{T_P}$

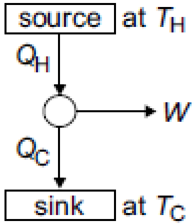
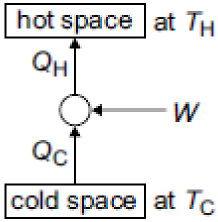
One-hour lessons	Specification Content
	Definitions of each term
2	3.10.6.1 Imaging techniques Use of a gamma-emitting radioisotope as a tracer; technetium-99m, iodine-131 and indium-111 and their relevant properties The properties should include the radiation emitted, the half-life, the energy of the gamma radiation, the ability for it to be labelled with a compound with an affinity for a particular organ
3	3.10.6.1 The Molybdenum-Technetium generator, its basic use and importance PET scans
4	3.10.6.3 Gamma camera Basic structure and workings of a photomultiplier tube and gamma camera 3.10.6.4 Use of high-energy X-rays External treatment using high-energy X-rays Methods to limit exposure to healthy cells
5	3.10.6.5 Use of radioactive implants Internal treatment using beta-emitting implants 3.10.6.6 Imaging comparisons Students will be required to make comparisons between imaging techniques. Questions will be limited to consideration of image resolution convenience and safety issues. *(Consolidation and exam questions practice)*

Option Unit: Engineering Physics (25 hours)

One-hour lessons	Specification Content
CHAPTER 20 ROTATIONAL DYNAMICS (10 hours)	
1	3.11.1.3 Rotational motion Angular displacement, angular speed, angular velocity, angular acceleration $\omega = \frac{\Delta\theta}{\Delta t}$ $\alpha = \frac{\Delta\omega}{\Delta t}$
2	3.11.1.1 Concept of moment of inertia $I = mr^2$ for a point mass $I = \Sigma mr^2$ for an extended object Qualitative knowledge of the factors that affect the moment of inertia of a rotating object Expressions for moment of inertia will be given where necessary
3	3.11.1.4 Torque and angular acceleration $T = Fr$ $T = I\alpha$ 3.11.1.3 Rotational motion Equations for uniform angular acceleration: $\omega_2 = \omega_1 + \alpha t$ $\theta = ½(\omega_2 + \omega_1)t$ $\theta = \omega_1 t + ½\alpha t^2$ $\omega_2^2 = \omega_1^2 + 2\alpha\theta$ Students should be aware of the analogy between rotational and translational dynamics
4	3.11.1.3 Rotational motion Representation by graphical methods of uniform and non-uniform angular acceleration
5 6	3.11.1.2 Rotational kinetic energy $E_k = ½I\omega^2$ Factors affecting the energy storage capacity of a flywheel
7	3.11.1.2 Rotational kinetic energy Use of flywheels in machines

One-hour lessons	Specification Content
	Use of flywheels for smoothing torque and speed, and for storing energy in vehicles, and in machines used for production processes
8	3.11.1.5 Angular momentum Angular momentum = $I\omega$ Conservation of angular momentum. Angular impulse = change in angular momentum $T\,\Delta t = \Delta(I\omega)$ where T is constant Applications may include examples from sport
9	3.11.1.6 Work and power $W = T\theta$ $P = T\omega$ Awareness that frictional torque has to be taken into account in rotating machinery
10	*(Consolidation and exam questions practice)*
CHAPTER 21 THERMODYNAMICS (7 hours)	
1	*(Revision of gas laws, ideal gas equation* $pV = nRT$*, absolute zero, kinetic theory model from Chapter 3)*
2	3.11.2.1 First law of thermodynamics Quantitative treatment of first law of thermodynamics: $Q = \Delta U + W$ where Q is energy transferred to the system by heating, ΔU is increase in internal energy and W is work done **by** the system Applications of first law of thermodynamics
3 4	3.11.2.2 Non-flow processes Isothermal, adiabatic, constant pressure and constant volume changes: $pV = nRT$ adiabatic change pV^γ = constant isothermal change pV = constant at constant pressure $W = p\,\Delta V$ Application of first law of thermodynamics to the above processes
5 6	3.11.2.3 The p–V diagram Representation of processes on this diagram Estimation of work done in terms of area below the graph Extension to cyclic processes: work done per cycle = area of loop Expressions for work done are not required except for the constant pressure case, $W = p\,\Delta V$
7	*(Consolidation and exam questions practice)*

One-hour lessons	Specification Content
CHAPTER 22 HEAT ENGINES (8 hours)	
1	3.11.2.4 Engine cycles Understanding of a four-stroke petrol engine cycle and a diesel engine cycle, and of the corresponding indicator diagrams A knowledge of engine constructional details is not required Comparison with the theoretical diagrams for these cycles Questions may be set on other cycles, but they will be interpretative and all essential information will be given
2	3.11.2.4 Engine cycles Input power = calorific value × fuel flow rate Indicated power as (area of p–V loop) × (no. of cycles per second) × (no. of cylinders) Output or brake power, $P = T\omega$ Friction power = indicated power – brake power Use of indicator diagrams for predicting and measuring power
3	
4	3.11.2.4 Engine cycles Engine efficiency; overall, thermal and mechanical efficiencies Overall efficiency $= \dfrac{\text{brake power}}{\text{input power}}$ Thermal efficiency $= \dfrac{\text{indicated power}}{\text{input power}}$ Mechanical efficiency $= \dfrac{\text{brake power}}{\text{indicated power}}$ Use of indicator diagrams for predicting and measuring efficiency
5	3.11.2.5 Second law and engines Impossibility of an engine working only by the first law Second law of thermodynamics expressed as the need for a heat engine to operate between a source and a sink Efficiency $= \dfrac{W}{Q_H} = \dfrac{Q_H - Q_C}{Q_H}$ Maximum theoretical efficiency $= \dfrac{T_H - T_C}{T_H}$
6	

One-hour lessons	**Specification Content**
	 Reasons for the lower efficiencies of practical engines Maximising use of W and Q_H for example in combined heat and power schemes
7	3.11.2.6 Reversed heat engines Basic principles and uses of heat pumps and refrigerators A knowledge of practical heat pumps or refrigerator cycles and devices is not required  Coefficients of performance: refrigerator: $\text{COP}_{\text{ref}} = \frac{Q_C}{W} = \frac{Q_C}{Q_H - Q_C} = \frac{T_C}{T_H - T_C}$ heat pump: $\text{COP}_{\text{hp}} = \frac{Q_H}{W} = \frac{Q_H}{Q_H - Q_C} = \frac{T_H}{T_H - T_C}$
8	*(Consolidation and exam questions practice)*

Option Unit: Turning Points (25 hours)

One-hour lessons	Specification Content
CHAPTER 23 ELECTRONS (7 hours)	
1	3.12.1.1 Cathode rays Production of cathode rays in a discharge tube
2	3.12.1.2 Thermionic emission of electrons The principle of thermionic emission Work done on an electron accelerated through a pd: $\frac{1}{2}mv^2 = eV$
3	3.12.1.3 Specific charge of the electron Determination of the specific charge of an electron, e/m_e, by any one method *(crossed fields)* Significance of Thomson's determination of e/m_e Comparison with the specific charge of the hydrogen ion
4	3.12.1.3 Determination of the specific charge of an electron, e/m_e, by any one method *(magnetic deflection)*
5	3.12.1.4 Principle of Millikan's determination of the electronic charge Condition for holding a charged oil droplet, of charge Q, stationary between oppositely charged parallel plates: $\frac{QV}{d} = mg$ Motion of a falling oil droplet with and without an electric field; terminal speed to determine the mass and the charge of the droplet Stokes' law for the viscous force on an oil droplet used to calculate the droplet radius: $F = 6\pi\eta rv$ Significance of Millikan's results Quantisation of electric charge
6	
7	*(Consolidation and exam questions practice)*
CHAPTER 24 WAVE PARTICLE DUALITY (12 hours)	
1	3.12.2.1 Newton's corpuscular theory of light Comparison with Huygens' wave theory in general terms The reasons why Newton's theory was preferred.
2	3.12.2.2 Significance of Young's double slits experiment Explanation for fringes in general terms, no calculations are expected Delayed acceptance of Huygens' wave theory of light
3	3.12.2.3 Electromagnetic waves

One-hour lessons	Specification Content
	Fizeau’s determination of the speed of light and its implications
4	3.12.2.3 Nature of electromagnetic waves Maxwell’s formula for the speed of electromagnetic waves in a vacuum $c = \dfrac{1}{\sqrt{\mu_0 \varepsilon_0}}$ where μ_0 is the permeability of free space and ε_0 is the permittivity of free space Students should appreciate that ε_0 relates to the electric field strength due to a charged object in free space and μ_0 relates to the magnetic flux density due to a current-carrying wire in free space
5	3.12.2.3 Hertz’s discovery of radio waves including measurements of the speed of radio waves
6	3.12.2.4 The ultraviolet catastrophe and black-body radiation Planck’s interpretation in terms of quanta
7	3.12.2.4 the discovery of photoelectricity The failure of classical wave theory to explain observations on photoelectricity Einstein’s explanation of photoelectricity and its significance in terms of the nature of electromagnetic radiation
8	3.12.2.5 Wave–particle duality de Broglie’s hypothesis: $p = h/\lambda$ $\lambda = \dfrac{h}{\sqrt{2meV}}$ Low-energy electron diffraction experiments; qualitative explanation of the effect of a change of electron speed on the diffraction pattern
9	
10	3.12.2.6 Electron microscopes Estimate of anode voltage needed to produce wavelengths of the order of the size of the atom Principle of operation of the transmission electron microscope (TEM)
11	3.12.2.6 Principle of operation of the scanning tunnelling microscope (STM)
12	*(Consolidation and exam questions practice)*
CHAPTER 25 SPECIAL RELATIVITY (6 hours)	
1	3.12.3.1 The Michelson-Morley experiment Principle of the Michelson-Morley interferometer Outline of the experiment as a means of detecting absolute motion Significance of the failure to detect absolute motion The invariance of the speed of light
2	3.12.3.2 Einstein’s theory of special relativity The concept of an inertial frame of reference

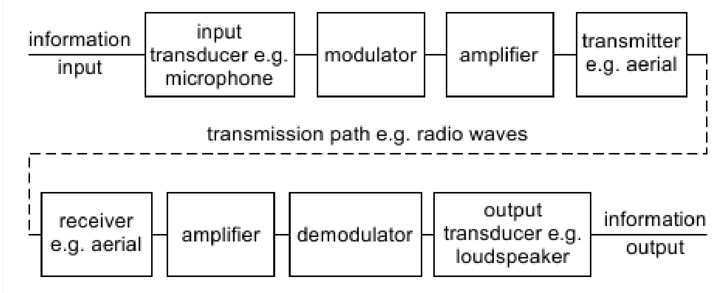
One-hour lessons	Specification Content
	The two postulates of Einstein's theory of special relativity: 1 physical laws have the same form in all inertial frames 2 the speed of light in free space is invariant 3.12.3.3 Time dilation Proper time and time dilation as a consequence of special relativity Time dilation: $t = \frac{t_0}{\sqrt{1 - \frac{v^2}{c^2}}}$
3	3.12.3.3 Time dilation: $t = \frac{t_0}{\sqrt{1 - \frac{v^2}{c^2}}}$ Evidence of time dilation from muon decay 3.12.3.4 Length contraction Length of an object having a speed v: $l = l_0\sqrt{1 - \frac{v^2}{c^2}}$
4	3.12.3.5 Mass and energy Equivalence of mass and energy, $E = mc^2$ $E = \frac{m_0c^2}{\sqrt{1 - \frac{v^2}{c^2}}}$ Graphs of variation of mass and kinetic energy with speed
5	3.12.3.5 Bertozzi's experiment as direct evidence for the variation of kinetic energy with speed
6	*(Consolidation and exam questions practice)*

Option Unit: Electronics (25 hours)

One-hour lessons	**Specification Content**
CHAPTER 26 DISCRETE SEMICONDUCTOR DEVICES (5 hours)	
1	*(Review of semiconductor materials; charge carriers as electrons and holes; n- and p- type materials; the p-n junction)*
2	3.13.1.1 MOSFET (metal-oxide semiconductor field-effect transistor) Use in N-channel, enhancement mode only is required Simplified structure, behaviour and characteristics Drain, source and gate V_{DS}, V_{GS}, I_{DSS} and V_{th} Use as a switch, use as a device with a very high input resistance
3	3.13.1.2 Zener diode Characteristic curve showing Zener breakdown voltage and typical minimum operating current Anode and cathode Use with a resistor as a constant voltage source Use to provide a reference source Use as a stabiliser is not required
4	3.13.1.3 Photodiode Characteristic curves and spectral response curves Use in photoconductive mode as a detector in optical systems Use with scintillator to detect atomic particles
5	3.13.1.4 Hall effect sensor *(The Hall effect)* Use as magnetic field sensor to monitor attitude Use in tachometer Principles of operation are not required *(Consolidation and exam questions practice)*
CHAPTER 27 ANALOGUE AND DIGITAL SIGNALS (5 hours)	
1	3.13.2.1 Difference between analogue and digital signals *(Nature of analogue and digital signals)* Bits, bytes Knowledge of binary numbers 1 to 10 The ability to carry out binary arithmetic is not required Effect of noise in communication systems Process of recovery of original data from noisy signal

2	3.13.2.1 Students should appreciate the use of a variety of sensors to collect analogue data Analogue-to-digital conversion: - sampling audio signals for transmission in digital form - conversion of analogue signals into digital data using two voltage levels
3	3.13.2.1 Analogue-to-digital conversion: - sampling rate - quantisation - effect of sampling rate and number of bits per sample on quality of conversion
4	3.13.2.1 Pulse code modulation Advantages and disadvantages of digital sampling *(Consolidation and exam questions practice)*
5	3.13.3.1 LC resonance filters Only parallel resonance arrangements are required *(Inductors and inductance)* Analogy between LC circuit and mass–spring system Inductance as mass analogy Capacitance as spring analogy Resonant frequency, $f_0 = \frac{1}{2\pi\sqrt{LC}}$ Energy (voltage) response curve Q factor, $Q = \frac{f_0}{f_B}$ f_B is the bandwidth at the 50% energy points *(Exam questions practice)*
CHAPTER 28 OPERATIONAL AMPLIFIERS (5 hours)	
1	3.13.3.2 The ideal operational amplifier The operational amplifier should be treated as an important system building block Operation and characteristics of an ideal operational amplifier: - power supply and signal connections - infinite open-loop gain - infinite input resistance Open-loop transfer function for a real operational amplifier, $V_{out} = A_{OL}(V_+ - V_-)$ Use as a comparator

2	3.13.4.1 Operational amplifier in inverting amplifier configuration Derivation of $\frac{V_{\text{out}}}{V_{\text{in}}} = -\frac{R_{\text{f}}}{R_{\text{in}}}$ Calculations Meaning of virtual earth, virtual-earth analysis 3.13.4.2 Operational amplifier in non-inverting amplifier configuration $\frac{V_{\text{out}}}{V_{\text{in}}} = 1 + \frac{R_{\text{f}}}{R_1}$ Derivation is not required
3	3.13.4.3 Operational amplifier in summing amplifier configuration $V_{\text{out}} = -R_{\text{f}}\left(\frac{V_1}{R_1} + \frac{V_2}{R_2} + \frac{V_3}{R_3} + \ldots\right)$ Derivation is not required Difference amplifier configuration $V_{\text{out}} = \left(V_+ - V_-\right)\frac{R_{\text{f}}}{R_1}$ Derivation is not required
5	3.13.4.4 Real operational amplifiers Limitations of real operational amplifiers Frequency response curve gain × bandwidth = constant for a given device *(Consolidation and exam questions practice)*
CHAPTER 29 DIGITAL SIGNAL PROCESSING (5 hours)	
1	3.13.5.1 Combinatorial logic Use of Boolean algebra as related to truth tables and logic gates $\overline{A}$ = **not** A $A \cdot B$ = A **and** B $A + B$ = A **or** B Identification of AND, NAND, OR, NOR NOT and EOR gates The gates should be treated as building blocks. The internal structure or circuit of the gates is not required
2	3.13.5.1 Identification and use of AND, NAND, OR, NOR NOT and EOR gates in combination in logic circuits Construction and deduction of a logic circuit from a truth table

3	3.13.5.2 Sequential logic *(The D-type flip- flop)* Counting circuits: binary counter Inputs to the circuit, clock, reset, up/down Outputs from the circuit
4	3.13.5.2 Counting circuits: - modulo-*n* counter from basic counter with the logic driving a reset pin - BCD counter - Johnson counter Inputs to the circuits, clock, reset, up/down Outputs from the circuits
5	3.13.5.3 Astables The astable as an oscillator to provide a clock pulse Clock (pulse) rate (frequency), pulse width, period, duty cycle, mark-to-space ratio Variation of running frequency using an external *RC* network Knowledge of a particular circuit or a specific device (e.g. 555 chip) will not be required *(Consolidation and exam questions practice)*
CHAPTER 30 DATA COMMUNICATIONS SYSTEMS (5 hours)	
1	3.13.6.1 Principles of communication systems Communication systems, block diagram of ‘real time’ communication system  Only the purpose of each stage is required 3.13.6.2 Transmission media Transmission-path media: metal wire, optical fibre, electromagnetic (radio, microwave)
2	3.13.6.2 *(Radio wave communication:)* ground waves, refraction and reflection of sky waves, diffraction of long-wavelength radiation around the Earth’s surface Satellite systems and typical transmission frequencies Students should recognise that up-links and down-links require different frequencies so that the receivers are not de-sensed Advantages and disadvantages of various transmission media. Students should consider transmission rate, cost, and security issues

3	3.13.6.4 Amplitude modulation (AM)and frequency modulation (FM) techniques Principles of modulation; bandwidth Details of modulation circuits for modulating a carrier signal with the information signal will not be required Carrier wave and information signal Graphical representation of both AM and FM modulated signals Students will be expected to identify the carrier frequency and the information frequency from a graph of the variation of signal voltage with time
4	Bandwidth requirements of simple AM: bandwidth = $2f_M$ Bandwidth requirements of simple FM: bandwidth = $2(\Delta f + f_M)$ Data capacity of a channel Comparison of bandwidth availability for various media
5	3.13.6.3 Time-division multiplexing Basic principles of time-division multiplexing *(Consolidation and exam questions practice)*