



**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** |
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| **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* =  *M* = |
| 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, *θ* ≈ *λ*/*D*  Students should be familiar with the rad as the unit of angle  Collecting power is proportional to diameter2 |
| 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)* |
| **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  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)* |
| 2 |
| 3 | 3.9.2.2 Absolute magnitude, *M*  Parsec and light year  Definition of *M*, relation to *m*:  *m* – *M* = 5 log |
| 4 | 3.9.2.3 Classification by temperature, black-body radiation  Stefan's law  *P*  = *σAT*4  and Wien's displacement law  *λ*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:    Temperature related to absorption spectra limited to hydrogen Balmer absorption lines: requirement for atoms in an *n* = 2 state |
| 6 | *(Consolidation and exam questions practice)* |
| **CHAPTER 13 STELLAR EVOLUTION** (6 hours) | |
| 1 | 3.9.2.5 The Hertzsprung-Russell (HR) diagram  Stellar evolution *(general overview from protostar to stable main sequence star)*  General shape (of HR diagram): main sequence, dwarfs and giants  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 |
| 2 |
| 3 | 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 |
| 4 | 3.9.2.6 Escape velocity > *c* for black holes  Calculation of the radius of the event horizon for a black hole, Schwarzschild radius, Rs ≈ 2*GM*/*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 |
| 5 | 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 *(introduction)* |
| 6 | *(Consolidation and exam questions practice)* |
| **CHAPTER 14 COSMOLOGY** (7 hours) | |
| 1 | 3.9.3.1 Doppler effect  Δ*f*/*f* = *v*/*c*  *z* = Δλ/λ = –v/c  for *v* << *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        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 × 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)  *(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  *(Consolidation and exam questions practice)* |
| 2 |
| **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* = *ρc*  and |
| 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 |
| 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  3.10.5.3 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–*μx*  *μ*m = *μ*/*ρ*  Differential tissue absorption of X-rays excluding details of the absorption process |
| 3 |
| 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:    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** |
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| **CHAPTER 20 ROTATIONAL DYNAMICS** (10 hours) | |
| 1 | 3.11.1.3 Rotational motion  Angular displacement, angular speed, angular velocity, angular acceleration |
| 2 | 3.11.1.1 Concept of moment of inertia  *I* = *mr*2 for a point mass  *I* = Σ*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* = *Iα*  3.11.1.3 Rotational motion  Equations for uniform angular acceleration:  *ω*2 = *ω*1 + *αt*  *θ* = ½(*ω*2 + *ω*1)*t*  *θ* = ω1*t* + ½*αt*2  *ω*22 = *ω*12 + 2*αθ*  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 | 3.11.1.2 Rotational kinetic energy  *E*k = ½*Iω*2  Factors affecting the energy storage capacity of a flywheel |
| 6 |
| 7 | 3.11.1.2 Rotational kinetic energy  Use of flywheels in machines  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 = *Iω*  Conservation of angular momentum.  Angular impulse = change in angular momentum  *T*Δ*t* = Δ(*Iω*)  where *T* is constant  Applications may include examples from sport |
| 9 | 3.11.1.6 Work and power  *W* = *Tθ*  *P* = *Tω*  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* = Δ*U* + *W*  where *Q* is energy transferred to the system by heating, Δ*U* is increase in internal energy and *W* is work done **by** the system  Applications of first law of thermodynamics |
| 3 | 3.11.2.2 Non-flow processes  Isothermal, adiabatic, constant pressure and constant volume changes:  *pV* = *nRT*  adiabatic change *pVγ* = constant  isothermal change *pV* = constant  at constant pressure *W* = *p* Δ*V*  Application of first law of thermodynamics to the above processes |
| 4 |
| 5 | 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* Δ*V* |
| 6 |
| 7 | *(Consolidation and exam questions practice)* |
| **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* = *Tω*  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 =  Thermal efficiency =  Mechanical efficiency =  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 =  Maximum theoretical efficiency =    Reasons for the lower efficiencies of practical engines  Maximising use of *W* and *Q*H for example in combined heat and power schemes |
| 6 |
| 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: COPref =  heat pump: COPhp = |
| 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: |
| 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:  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* = 6π*ηrv*  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  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  where is the permeability of free space andis the permittivity of free space  Students should appreciate that relates to the electric field strength due to a charged object in free space and 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/λ*  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  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: |
| 3 | 3.12.3.3 Time dilation:  Evidence of time dilation from muon decay  3.12.3.4 Length contraction  Length of an object having a speed : |
| 4 | 3.12.3.5 Mass and energy  Equivalence of mass and energy,  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)

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| **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,    Energy (voltage) response curve  *Q* factor,    *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    Calculations  Meaning of virtual earth, virtual-earth analysis  3.13.4.2 Operational amplifier in non-inverting amplifier configuration    Derivation is not required |
| 3 | 3.13.4.3 Operational amplifier in summing amplifier configuration    Derivation is not required  Difference amplifier configuration    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    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  Bandwidth requirements of simple AM:  bandwidth = 2*f*M  Bandwidth requirements of simple FM:  bandwidth = 2(Δ*f*  + *f*M)  Data capacity of a channel  Comparison of bandwidth availability for various media |
| 4 |
| 5 | 3.13.6.3 Time-division multiplexing  Basic principles of time-division multiplexing  *(Consolidation and exam questions practice)* |