Notes: this syllabus is designed to meet the needs of those carrying on to “A” level Physics and those leaving school after senior 4 or (UCE). The Syllabus emphasises the understanding of fundamental principles and an experimental approach based on individual experimental approach based on individual experimental work. Some experiments, however, might be best done by demonstration. But even in such instances, students should be involved in the design, performance, recording, etc. Some of the examination questions will demand knowledge and understanding of practical situations. Candidates will be at a disadvantage if a practical approach has not been used. SI Units should be used through out the teaching of this syllabus. Where other units must be used, the related SI Units must also be taught.

Aims:

1. The general aims of teaching Physics are:
   a) The making of a society that knows about Physics and enjoys the fruits of physics.
   b) The making of a society that understands everyday phenomena: natural and artificial and their scientific explanations
   c) The production of a large number of people capable of harnessing natural resources scientifically and technically in an innovative way for the service of society.
   d) The production of an effective team of physicists working in Physics for the advancement of knowledge.
2. The teacher is expected to present the course in a sequence that emphasises the experimental, the experimental-investigative and the fundamentally coherent aspects of the subject to reflect the following objectives
   (a) to help the student understand the world around us.
   (b) to make the student aware of the effects of scientific discoveries and knowledge on every day life through some applications of physics.
   (c) to enable the student to develop an experimental attitude of mind by performing experiments in the school.
   (d) to familiarise the student with scientific methods including techniques of observation, measurement and drawing appropriate conclusions.
   (e) to prepare the student for further studies in physics or for training in which an elementary understanding of physics is required.

3. **Testable Objectives**

   In the summative evaluation of the achievement of the above objectives, tests and examinations meant for UCE level must be designed to reflect acquisitions of the following testable objectives:

   (a) **Knowledge:**
      i. Knowledge of terminology.
      ii. Knowledge of specific facts.
      iii. Familiarity with experiments suggested in the syllabus.
      iv. Knowledge of common principles and generalisations identified in the syllabus.

   (b) **Comprehension:** Ability to:
i. Explain standard phenomena from laws and models and to describe standard experiments met with before.

ii. Translate between various forms of information presentation.

iii. Use standard methods to solve familiar numerical types of problems.

iv. Draw conclusions from experiments of a straightforward type.

(c) **Application and higher abilities:** Ability to: -

   i. Analyse presented information.

   ii. Synthesize ideas from presented analyses and otherwise.

   iii. Apply laws and generalizations already learnt to new situations.

   iv. Devise experiments to test hypothesis and statements of models.

   v. Exercise evaluative judgment on suitability and results of scientific procedures.

(d) **Practical abilities:**

The written tests will demand knowledge of and familiarity with experiments in physics relevant at this level. The practical component of the examination will further test acquisition of the following abilities:

   i. Application of knowledge to practical situations.

   ii. Manipulation of apparatus and performing experiments.

   iii. Making and recording observations accurately.

   iv. Presentation of data in appropriate form.

   v. Drawing conclusions from observations made.

   vi. Assessing suitability of procedure, experimental and observations made in support of the conclusions.
Examination Format:
There will be three papers.

Paper 1: (2 ¼ hours).
It will consist of two sections, A and B. section A will contain 40 objective test items and section B will contain ten structured short answer questions set on any part of the syllabus. All questions will be compulsory.

(80 marks)

Paper 2: (2 ¼ hours)
It will consist of eight semi-structured/essay type questions drawn evenly from the whole syllabus. Candidates will be required to answer five questions

(80 marks)

Paper 3: (2 ¼ hours)
It will consist of three questions. Question 1 will be compulsory. In addition candidates will be required to answer one of the questions 2 or 3.

(40 marks)

Detailed syllabus:
The syllabus consists of the outline and the notes. These must be read together in order to appreciate the details of the syllabus in its entirety. The syllabus does not represent the teaching order of the content.

FORCE AND ENERGY

Outline of the syllabus          Notes
1.  Motion
   Speed
   Displacement/Time graphs.
   Velocity/Time graph.
   Velocity and acceleration.

   Definition
   Quantitative treatment of uniform acceleration using graphical methods.
<table>
<thead>
<tr>
<th>Acceleration due to gravity.</th>
<th>The use of formulae:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Displacement = velocity x time.</td>
<td></td>
</tr>
<tr>
<td>Velocity = acceleration x time,</td>
<td></td>
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<tr>
<td>is expected. Quantitative treatment of</td>
<td></td>
</tr>
<tr>
<td>non-uniformly accelerated motion.</td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Projectiles treated qualitatively.</th>
<th>Treatment to be in terms of independence of</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>vertical and horizontal motions</td>
</tr>
</tbody>
</table>

2. **Force:**

| Various types of forces: gravitational | effect of force on shape and motion |
| Forces including weight, electrostatic, | Weight as a force measured in Newtons |
| magnetic, frictional and elastic forces. | |
| Friction between solid surfaces and in |
| fluids. |
| Quantitative demonstration of static |
| and dynamic friction. |
| Forces as a vector. |

<table>
<thead>
<tr>
<th>Vectors and scalars</th>
<th>Addition of vectors and application</th>
</tr>
</thead>
<tbody>
<tr>
<td>to resultant velocity and resultant</td>
<td></td>
</tr>
<tr>
<td>force.</td>
<td></td>
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<tr>
<td>Composition and resolution of vectors using</td>
<td></td>
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<tr>
<td>graphical and analytical methods for vectors</td>
<td></td>
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<tr>
<td>at right angles only.</td>
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</tbody>
</table>

3. **Force and Motion**

| Mass (inertia) as a property of matter | Relation between force, mass and |
| Newton’s the three laws of motion. | acceleration by experimental |
|                                     | treatment with ticker-timer and |
|                                     | trolley or other suitable method. |
| Understanding of Newton’s three |
| laws of motion in the following ways |
| Law 1: \( F=0 \) implies constant velocity |
including zero speed.

Law 2: \( F = ma \).

Law 3: if body A exerts a force on body B, then body B exerts a force equal in magnitude and opposite in direction on body A. Then Newton (N) to be defined from \( F = ma \).

Simple numerical problems include those on action and reaction.

Qualitative treatment of motion in a curved path.

Examples be limited to circular motion only.

Linear momentum.

Conservation of momentum

Qualitative illustration of the application of momentum conservation in turbines, jet engines and rockets.

4. **Turning affects of forces:**

The lever.

Principle of moments.

Practical applications: Spanners, gears, wheel barrow or a handcart (Stationary and in motion).

Center of gravity treated qualitatively.

Relation of position of centre of gravity to stability of equilibrium by experimental treatment.

5. **Energy sources and changes:**

Qualitative study of energy transformations.

Primary sources of energy indicating the form in which energy is contained, including solar, nuclear, oil, water, wind, biological
Conversion from each of these sources to other more useful forms of energy, including electricity, gas (including biogas), charcoal, food. Emphasis on relevance of energy Sources and conversions to local needs

Quantitative of potential kinetic and electric energy.

Gravitational potential
energy = mgh

Kinetic energy = \( \frac{1}{2} mv^2 \)

Definition of the joule (J)

Energy input and output, and efficiency applied to simple machines, e.g. pulley systems, and to electrical devices e.g. motors.

Simple heat engines e.g. the internal-combustion engine, refrigerators.

Experimental treatment of simple machines, including pulley systems, spanners, screws, wheels and axles, gears.

6. **Energy Transfer:**

Energy transfer by: electro-magnetic radiation, heat conduction and convection.

Effect of the nature of the surface on absorption and emission of radiation. Application e.g. vacuum flask, thermal insulation, hot water supply system including solar heating system.

7. **Power:**

Rate of energy change. Practical applications including heaters, motors, etc.

Definition of the watt:

1 W = 1 joule/second or 1 Js\(^{-1}\).
8. **Pressure:**

- Force per unit area.
- Measurement of pressure in fluids.
- Variation with depth and density.
- Practical applications, demonstration of transmission of pressure, manometers Bourdon gauge.

1 Pa = 1 Nm$^{-2}$

Pressure, $P = \rho g$.

Any simple experiment to measure atmospheric pressure.

Practical applications: water supply, hydraulic brakes force and lift pumps.

Archimedes’ Principle.

Experimental treatment of upthrust and flotation leading to Archimedes’ principle.

Fluid flow; steam-lines and turbulence.

Practical applications: boats and balloons.

Terminal velocity.

Qualitative treatment only.

**PROPERTIES OF MATTER**

9. **Characteristics of material**

- Appearance
- Classification.
- Density.

Use of measurements obtained from the techniques below to find density (use of displacement cans and density bottles is not needed).

Measurements of:

i. Length: using ruler, tapes, calipers (use of vernier scales or micrometer is not required.) Units: km, m, cm, mm.

ii. Mass: using balances. Units: tonne, kilograms, (kg) gramme (g).
iii. Time: using clocks.  
Units: second, minutes, hours.

iv. Area: from measurements of lengths. Units: \( m^2 \) (cm\(^2\), mm\(^2\)).

v. Volume: from measurements of length of regular shapes, displacement methods for irregular shapes using measuring cylinders. Units: \( m^3 \), \( dm^3 \), (litres), \( cm^3 \), \( mm^3 \).

Importance of significant figures and standard form (scientific notation).

No calculated result to be expressed to more significant figures than those of original data.

Orders of magnitude including very small, e.g. size of molecules, and very large, e.g. distances of stars and galaxies.

Convenience of standard form for large and small numbers and for indicating number of significant figures.

Estimation of length, mass, and time when it is not possible or necessary to make accurate measurements. Estimation of mass of a sheet of paper. Use of pulse (blood pulse) to measure time.

10. **Particulate nature of matter:**
Growing of crystals
Cleavage and regularity of crystals.
Surface tension.

Existence of surface tension demonstrated without detailed theoretical treatment
Brownian motion
Diffusion
The oil-film experiment leading to particulate module of matter.

Finding the mean volume, $V$ of a drop of oil from the volume of many drops and calculating the thickness, $t$ of the film from the formula for the volume of a cylinder, i.e. $V = \pi r^2 t$ to give $t = \frac{V}{\pi r^2}$ for circular oil-patch of radius $r$.

11. **Thermal properties of matter:**

Physical properties of matter which change with temperature.

Examples of physical properties which change with temperature: length, volume, density, electrical conductivity, thermoelectric e.m.f, radiation frequency of electromagnetic radiation emitted by hot bodies.

Simple kinetic theory of matter.
Development of the following, based where possible, on simple kinetic theory: temperature, Celcius and Kelvin scales of temperature, the three phases of matter, change of phase, boiling and melting points, saturated and unsaturated vapours.

Absolute zero of temperature.
relation between temperature intervals on the two scales.

Specific heat capacity.
Specific latent heat: experimental determination for specific latent

Candidates will be expected to know the principles of some method of measuring specific heat
heats of fusion and vaporization capacity, but questions will not be set requiring a particular method to be described. Numerical problems may be set. Definition of specific heat capacity As a ratio is not accepted.

Thermal expansion and applications Volume change due to change of phase treated qualitatively.
treated qualitatively.

Laws of pressure and volume change One simple experiment to illustrate each gas law.
With temperature for a fixed mass of gas.

Boyle’s law. Simple experiment to illustrate Boyle’s law. The combination of the three laws to give the general gas law:

\[ \lambda = \frac{PV}{T} = \text{constant}, \]

For a fixed mass of gas, assumed ideal. Mention should be made that this does not hold exactly for any real gas.

12. Mechanical properties of materials:
Stretching springs of wires leading to Hooke’s law and its limitation. Experiments on stretching to breaking point of a copper wire and stretching a helical spring. Stress and strain. Compression and tension forces.
Strength, stiffness, ductility and brittleness.

Bending of beams and effect of shape.

Notch-effect and fibre reinforcement.

Structures: supports of roofs, water tanks and bridges.
Reinforcement of concrete. Struts and ties.

IONIZATION AND RADIOACTIVITY.

13. Electrons:
Thermionic effect.
Electron beams (cathode rays):
deflection in electric and magnetic fields, treated qualitatively.

Use of the oscilloscope to show wave form and measure (peak) potential difference.

Millikan’s experiment is not required but the concept of the electron as the basic quantity of electric charge is required.

Outline of the principle of operation of the C.R.O in terms of electron gun, deflecting plates and fluorescent screen. Extension of application of oscilloscope to T.V receiver with reference to time base and brightness only.
14. **The nuclear model of the atom:**
The simple nuclear model of the atom.
Nuclides and isotopes.
Nuclear reactions, fission and fusion

The atom as consisting of protons and neutrons in the nuclear and orbiting electrons.
Mention of fusion is adequate, i.e. fusion reactions in the sun and stars
Radioactive products of nuclear reactions.
Outline of the use of nuclear energy in the generation of electricity and in bombs.

15. **Radioactivity**
Ionizing effects of the α and β particles and γ-rays.

Behavior in magnetic and electric fields and identification of the radiations. Effect of density of materials on absorption of the radiations.

Effect on parent nucleus of emission of α and β-particles and γ-rays.

Half life.

Concept and definition of half-life
Effect of half-life.

Health hazards and safety precautions.

Safety precautions including shielding, direction and distance, time of exposure, and effect of half-life.

Application of radioactivity.

Industrial, biological and medical uses
16. *Characteristics of waves on ropes, springs and water:*

- **Transverse and longitudinal waves.** Experiments with rubber tubing, slinky and ripple tanks to be the basis for teaching.
- **Progressive and standing waves** treated qualitatively. Demonstration of nodes and antinodes for standing waves, e.g. on a slinky.
- **Velocity, V, frequency, f, wave length λ and amplitude, a.** The wave-velocity equation \( V = f\lambda \) to be supported by an analogy but not verified experimentally. The direction of propagation of a wave and its geometrical relation to wave forms.
- **Reflection including laws of reflection.** Reflection at plane and curved surfaces. Image formation using plane and circular wavefronts reflected by plane and curved barriers. The concept of real and virtual images.
- **Refraction treated qualitatively.** Demonstration of refraction in ripple tank experiments. Refractive index as a ratio of velocity is not required.
- **Interference and diffraction.** Simple demonstration of interference and diffraction of patterns in a ripple tank only is expected.
17. **Behavior of sound waves.**

Reflection, speed, frequency and audio-frequency range.

Production of sound by vibrating bodies.

Necessity of a medium for propagation of sound.

Echoes and persistence of hearing.

A simple experiment to measure the speed of sound in air.

Resonance.

Experiments to demonstrate Resonance using a coupled pendulum and air tubes to illustrate mechanical and acoustical cases.

Subjective properties and sound waves.

Simple treatment of pitch.

loudness and quality.

Frequency and pitch.

Effect of length and tension of a given wire on frequency of vibration and relating this to string instruments.

18. **Behavior of light.**

Rectilinear propagation: shadows, eclipses, pin-hole camera.

Simple experimental work on image formation is required.

Reflection in plane and curved mirrors.

Applications of reflection.

Applications of curved mirrors including solar concentrators and car headlamps.
<table>
<thead>
<tr>
<th>Topic</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Refraction.</td>
<td>Qualitative treatment of real and apparent depth.</td>
</tr>
<tr>
<td>Refractive index.</td>
<td>Use of the relation $n = \frac{\sin i}{\sin r}$</td>
</tr>
<tr>
<td>Determination of refractive index by a simple method, e.g. using a</td>
<td>Relation of critical angle to refractive index.</td>
</tr>
<tr>
<td>rectangular glass block, a triangular prism and tracing rays</td>
<td>Application of total internal reflection in prisms.</td>
</tr>
<tr>
<td>through them.</td>
<td>Dependency of the refraction of light on frequency (wave length).</td>
</tr>
<tr>
<td>Concept of critical angle.</td>
<td>Colour of materials treated simply in terms of absorption, reflection and</td>
</tr>
<tr>
<td></td>
<td>transmission of various colours of the spectrum.</td>
</tr>
<tr>
<td>Total internal reflection.</td>
<td>Simple determination of the focal length of a thin converging lens.</td>
</tr>
<tr>
<td>Dispersion of white light.</td>
<td>Only graphical (scale diagram) methods of locating images and their</td>
</tr>
<tr>
<td></td>
<td>magnification.</td>
</tr>
<tr>
<td>Principle focus and focal length of thin lenses.</td>
<td>Treatment using ray diagrams for simple arrangement to obtain</td>
</tr>
<tr>
<td></td>
<td>i. a virtual image (magnifying glass);</td>
</tr>
<tr>
<td></td>
<td>ii. a diminished real image (eye</td>
</tr>
</tbody>
</table>
and camera); and

iii. a magnified real image
(projectors) by one converging
lens only expected.

The lens camera developed from
the pinhole camera.

19. **The electromagnetic spectrum:**
Brief survey of radio and microwave,
infra-red, visible and ultra violet waves,
X-rays and γ-rays, including their general
properties in terms of velocity, c, frequency f
and wavelength λ.

Conditions under which the electro-
magnetic waves are generated. X-ray tube in terms of thermionically
emitted electrons accelerated to a
target where their kinetic energy is
is converted to heat energy and
X-rays. Details of what happens
within the target are not required.

Effects of each major band of Health hazards from the spectrum.
the spectrum on matter safety precautions.

Application of each major band use of X-rays in industry and
medicine (one use in each case. See
also use of radioactivity).

**ELECTRICITY AND MAGNETISM**

20. **Electrostatics:**
Evidence for two types of charge. Evidence for two types of charge
demonstrated experimentally. The
electroscope and its use in indicating
Electron movement and its connection with:

i. electrification by friction and charging by induction.

ii. conductors and insulators.

Electric field patterns around objects of different shapes preferably investigated experimentally:

i. around point charge (s);

ii. between a charged point and a plate;

iii. between two parallel plates;

iv. inside and outside hollow conductors.

Application: lighting and lightening conductor.

21. **Magnetism and electromagnetic effects:**

**Permanent magnets.**

Behaviour of permanent magnets in the earth’s field.

Attraction and repulsion between permanent magnets.

**Action of permanent magnets on various materials.**

Ferromagnetic and non-ferro magnetic materials.

The earth’s magnetic field.

Use of the magnetic compass.

Magnetic fields around permanent
magnets and around wires and coils carrying electric current.

Electromagnets and applications in the electric bell and the ticker-timer

Neutral points.

Magnetic induction and magnetic screening.

Magnetisation and demagnetisation.

Methods of magnetisation limited to single touch and by an electric current only. 
Simple domain theory of magnetism.

Forces on conductor carrying current in a magnetic field.

Demonstration of the factors affecting the magnitude and the direction of the force. Knowledge of the rules for finding the direction of the force is required, but questions will not be set on statement of rules. 
Practical applications: moving coil galvanometer, moving coil loud speaker, d.c. motor.

<table>
<thead>
<tr>
<th>22. Electric potential difference and current:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sources of e.m.f cells and accumulators, a.c. and d.c. generators, thermocouples, crystal generators, photocells.</td>
</tr>
</tbody>
</table>
| Chemical reactions, electromagnetic induction, thermo-electric effect, piezo-electric effect and photoelectric effect used experimentally to demonstrate generation of e.m.f. 
Structure of the simple cell, the dry Cell and the accumulator (both lead acid and Nife cells) and their |
Care and maintenance of accumulators.

Practical application of sources of e.m.f: in the dynamo and microphone, thermocouple, crystal pick-up and photocell.

Potential difference (p.d) and the definition of its unit, the volt.

Practical demonstration of drop in terminal pd.

Cells in series and parallel to be demonstrated.

Use of circuit boards and torch bulbs to indicate passage of current is a convenient method.

The ampere as the fundamental unit of electric current

Connection with the flow of electric charge through the relation: 1Coulomb =1 ampere-second.

Conductors and insulators.

Use of ammeters and voltmeters in circuits.

Electric current in metal conductor treated in terms of drift of free electrons.

Electrolytes and non-electrolytes.

Demonstration of passage of current through liquids.

Practical application in electroplating.

(Study of electrolysis and details of chemical equations are not required)
<table>
<thead>
<tr>
<th>Topic</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>P.d. current variations for linear and non-linear resistors.</td>
<td>P.d. current variation to be demonstrated for wires, carbon resistors, lamps, semi-conductor diodes, thermistors, neon tubes and electrolytes.</td>
</tr>
<tr>
<td>Resistance and its unit.</td>
<td>Qualitative treatment of resistance with temperature is included.</td>
</tr>
<tr>
<td>Resistors in series and parallels.</td>
<td></td>
</tr>
<tr>
<td>Calculation of effective resistance, including conversion of galvanometers.</td>
<td></td>
</tr>
<tr>
<td>Heating effect of an electric current. Electric power.</td>
<td>Quantitative treatment of the energy converted, and the power, is expected. The relation between the ampere, the volt and the watt.</td>
</tr>
<tr>
<td><strong>23. Electromagnetic induction:</strong></td>
<td></td>
</tr>
<tr>
<td>E.m.f. induced by changing magnetic field linking a conductor.</td>
<td>Qualitative experiments on factors affecting the magnitude and direction of the induced e.m.f. Formulae are not required. Simple a.c and d.c generators (only single-coil treatment of alternators and dynamos).</td>
</tr>
<tr>
<td>Alternating current.</td>
<td></td>
</tr>
<tr>
<td>Transformer.</td>
<td>R.m.s. value of terminal p.d treated qualitatively in terms of heating effect.</td>
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</tr>
</tbody>
</table>
In terms of $V_s = N_s$  
$V_p = N_p$
for the ideal case.

Rectification of a.c.  
Production of unsmoothed output only.

**24. Electricity supply:**

Generation of electrical energy.  
Steady and pulsating d.c., alternating current.
Advantages of a.c. over d.c in mains supply.

Distribution of electrical energy.  
The grid system for single phase only.
Advantages of transmission at high voltage.
Function of the transformer.

Wiring in buildings.  
Safety precautions: switches and their position, circuit breakers and fuses, earthing.
The ring main is not required.

Cost calculations.  
The kilowatt-hour, kWh, as a unit of commercial supply and its relation to the joule.