Physics 7540

This subject may be taken at both the May/June and January examinations.

Note: This syllabus contains minor corrections to the previous version, in particular to paragraph 3.15.

Introduction

The syllabus is suitable for a two-year course of physics occupying about 150 hours, following introductory courses in science and mathematics. The syllabus should, however, be regarded by teachers as a framework round which to fit their individual courses rather than specifying a list of items to be taught.

It is hoped that the course will be taught in a spirit of investigation, and it is expected that the student will be involved in practical work wherever relevant.

Aims

- To develop a curiosity about physical phenomena into an informed appreciation of the physical world. The course should thus be more than the rote learning of stated facts and should aim to promote an awareness of physics as a satisfying intellectual discipline.
- To produce a course which develops scientifically literate citizens as well as providing for those who will make direct use of their studies in the subject. Thus wherever appropriate the teaching should arise out of or lead directly towards the applications of physics.

Assessment Objectives

On completion of the course the students should have:

(a) an adequate background knowledge and an understanding of the concepts and principles which are fundamental to physics, and of the scientific terminology, definitions, main facts, laws and formulae within the compass of the syllabus. They should be able to express such knowledge and understanding in written and mathematical form at an appropriate level;

(b) an appreciation of the relevance of physics to everyday situations, e.g., in the home;

(c) the ability to handle apparatus, make accurate observations and assess their significance in drawing conclusions;

(d) the ability to design and evaluate an experiment to investigate a problem.

In the examination, candidates will be expected to demonstrate the following skills.

Comprehension, which includes the ability to understand information, and interpret, extract and explain facts presented in it.

Activities which may be required in the examination, include:

- expressing a mathematical law in verbal terms,
- using a known formula to calculate a physical quantity,

- describing an experimental technique,
- reading information from a graph,
- extracting appropriate data from a table,
- making straightforward deductions from extracted data,
- expressing experimental results in a graphical form,
- explaining the physics principles behind the design of apparatus with which the student is familiar,
- explaining simple phenomena in terms of the laws of physics.

Application and evaluation which include the ability to solve problems verbally, mathematically, graphically and experimentally, and the ability to draw conclusions, both theoretical and practical.

Activities which may be required in the examination include:

- explaining simple effects with which the student is unfamiliar,
- solving numerical problems involving two or more stages where the laws involved are not immediately obvious,
- interpretation of graphs involving, for example, the measurement of the slope of a straight line,
- drawing theoretical conclusions from non-standard graphical results,
- identifying flaws in experimental technique by inspection of the results,
- designing and evaluating an experimental investigation of a problem.

Scheme of Assessment

The examination will consist of two compulsory papers. Together the papers will be designed to examine the candidate's understanding of the whole syllabus, and will test the following range of abilities:

knowledge	40%
comprehension	40%
higher abilities (application, analysis, evaluation, etc.)	20%

Paper 1 will carry 40% of the total subject mark and Paper 2 will carry 60%.

Paper 1 (1 hour 15 minutes) will contain eleven compulsory short questions which will be answered in spaces provided in the question booklet. Each question will usually be based mainly on the content of one section of the syllabus.

Paper 2 (2 hours) will contain five compulsory questions to be answered in an answer book. Any calculations required will be simple and direct.

The syllabus mentions, as examples, only a few of the more common applications. Examination questions will not generally refer to particular applications, except where the emphasis in the question is primarily on the principles of physics involved, when sufficient detail will be given in the question to enable a candidate unfamiliar with the application to understand it.

Except where the syllabus refers to a particular device, examination questions relating to experimental techniques will be so structured that a candidate who has not used a particular piece of apparatus will be given enough information to understand the situation forming the background to the question.

It is recommended that candidates have available a calculator with at least the following keys when answering papers in this subject:

$+, -, \times, \div, x^2, \pi, x^2, 1/x, \sqrt{x}, x^y$

sine, cosine and tangent and their inverses in degrees and decimals of a degree

Students should be familiar with numbers written in standard form.

Questions will be set in SI units.

The value of the acceleration of free fall, *g,* quoted in the papers will be 10 m/s^2.

Syllabus Content

1. Force

Forces in newtons. Types of force: weight, contact forces, drag forces, electrostatic and electromagnetic forces. (When other forces arise some explanation will be given.)

Scalar and vector quantities. Force as a vector quantity. Newton’s third law of motion.

Newton’s first law of motion and the concept of inertia. Newton’s second law of motion, mass and force. The newton as a kilogram metre/second^2.

Candidates will be expected to:

1.1 use forces measured in newtons,

1.2 express any force as the push or pull of one body on another,

1.3 identify various types of force, (e.g., gravitational, electrostatic, etc),

1.4 distinguish between solid-solid contact forces involving tangential frictional forces and perpendicular reaction forces,

1.5 know that solid-fluid drag forces (e.g., the push of the air on a car) increase with speed,

1.6 understand that in Newton’s third law the two relevant forces act on different bodies,

1.7 draw free-body force diagrams for particles and for extended bodies, i.e., diagrams showing the chosen object isolated from its surroundings but acted on by all the forces which the surroundings produce,

1.8 distinguish between vector and scalar quantities,

1.9 appreciate the vector nature of a force,

1.10 add vector forces along a line and resolve a force into two perpendicular resolved parts,

1.11 associate weight with the pull of the Earth on a body,

1.12 recall that an object which is stationary or is moving with uniform speed in a straight line has zero unbalanced force acting on it, 1.13 describe experimental work on force, mass and acceleration using dynamics trolleys,

1.14 understand that an unbalanced force makes an object accelerate and that $\alpha \propto F$, while for a given unbalanced force $a \propto 1/m$,

1.15 use Newton's second law in the form

mass × acceleration = unbalanced force

to solve simple problems involving motion in a straight line,

1.16 associate a newton with a kg m/s^2 and recall that at the Earth's surface one kilogram has a weight of 10 newtons,

1.17 apply Newton's second law qualitatively to situations such as the use of a hammer or the packaging of eggs,

1.18 relate Newton's laws of motion to the movement of vehicles and animals on or above the Earth's surface,

1.19 make use of an understanding of the physical principles involved in the study of force to situations or to devices which may or may not be familiar.

2. Linear Motion

Velocity and acceleration: laboratory studies involving measuring the distance moved in fixed time intervals, and measuring the time taken to move a given distance. Motion graphs and their interpretation.

The analysis of uniformly accelerated motion. Measuring *g*, mass and weight.

Linear momentum and its conservation in one dimension. Kinetic energy (see section 3).

Candidates will be expected to:

2.1 recall that the average speed of an object is found by dividing the distance moved by the time taken,

2.2 extract information about the motion of a body from a ticker-timer tape,

2.3 extract information about the motion of a body from multiflash photographs,

2.4 translate between different forms of data relating to motion, e.g., draw a velocity-time graph from tabulated information or from a word description,

2.5 recall that the average acceleration of a body is calculated as the change of velocity divided by the time,

2.6 recall that velocity and acceleration are vector quantities,

2.7 relate velocity to the slope of a displacement-time graph both qualitatively and quantitatively,

2.8 relate acceleration to the slope of a velocity-time graph both qualitatively and quantitatively,

2.9 determine distance travelled from the area between a velocity-time graph and the time axis, 2.10 make calculations about linear motion with constant acceleration using the relationships $a = (v - u)/t$ and $s = (v + u)\, t/2$,

2.11 recall and use the relationships $s = \frac{1}{2} at^2$ for the distance covered from rest by a body moving with constant acceleration,

2.12 associate weight with the pull of the Earth on a body,

2.13 know that the weight of a body may vary from place to place but that its mass does not change,

2.14 describe how to determine the acceleration of free fall, *g*, using direct measurements of length and time,

2.15 define linear momentum as mass times velocity and attribute units to it,

2.16 predict the results of simple collisions and explosions along a line using the principle of the conservation of linear momentum,

2.17 describe experimental work on kinetic energy and the conservation of linear momentum using dynamics trolleys,

2.18 make use of an understanding of the physical principles involved in a study of linear motion to situations or to devices which may or may not be familiar.

3. Energy

Energy sources. The conservation of energy. (This work permeates the whole syllabus and cannot be seen in isolation.) Energy transfer and efficiency. (Where necessary, the design of a particular machine, e.g., a pulley system or a system of gears, will be given.) Measuring energy transfer. Work and heat; the joule. Power, the watt

A knowledge of kinetic energy as $\frac{1}{2} mv^2$, and of gravitational potential energy as *mgh*. Quantitative study of internal energy. Specific heat capacity, $mc\,(\theta_1 - \theta_2)$. Measuring *c*. Qualitative study of latent heat. Conduction, convection and radiation.

Candidates will be expected to:

3.1 describe the different forms of energy: chemical, nuclear, electromagnetic radiation (heat and light), internal or random thermal, mechanical (kinetic, gravitational potential, elastic), electrical,

3.2 be familiar with the principle of the conservation of energy,

3.3 identify and describe devices and processes in which energy is converted from one form to another,

3.4 calculate energy transfer (or work done) as the force times the distance moved in the direction of the force when the force moves its point of application,

3.5 recall that energy is measured in newton metre or joule and that rate of working or power is measured in joule per second or watt,

3.6 solve problems involving the efficiency of energy conversion where a process is fully specified,

3.7 solve elementary problems involving changes in gravitational potential energy as *mgh* where *h* is the vertical distance moved by a body of mass *m* near the Earth's surface, 3.8 understand that moving bodies have kinetic energy which is transferred when they are stopped,

3.9 recall that the kinetic energy of a moving body is $\frac{1}{2}mv^2$ and use this expression in simple problems,

3.10 solve elementary problems involving the principle of the conservation of energy, including those involving internal energy,

3.11 appreciate that the hotter a substance is, the more energy its particles (atoms, molecules, etc.) have,

3.12 appreciate that changes of state are associated with changes in internal energy at constant temperature,

3.13 recall the meaning of specific heat capacity,

3.14 describe how to measure the specific heat capacity of a liquid or metal using direct methods involving an electrical heating coil,

3.15 understand that the change in internal energy = mass × specific heat capacity × temperature change,

3.16 recall that energy transfer may take place by three processes: conduction, convection and radiation,

3.17 recall that different materials conduct internal energy at different rates and describe the consequences of these differences,

3.18 understand the role of natural convection in everyday phenomena,

3.19 describe experiments with good and bad emitters and with good and bad absorbers of infra-red radiation,

3.20 make use of an understanding of the physical principles involved in a study of energy to situations or to devices which may or may not be familiar.

4. General Physics

The turning effect of a force; the principle of moments. Centre of gravity.

The stretching of threads and springs; Hooke's law and the elastic limit. Density. The expansion and contraction of substances associated with a change in temperature.

Pressure; pressure in fluids; the pascal. The transmission of pressure in liquids. Pressure difference as ρgh; manometers. (The setting up of mercury barometers will *not* be examined.)

Candidates will be expected to:

4.1 calculate the moment of a force about a point as the magnitude of the force multiplied by the perpendicular distance of the line of action of the force from the point,

4.2 know that the weight of a body acts through its centre of gravity,

4.3 use the principle of moments for a simple system of parallel forces acting in one plane,

4.4 understand that two equal and opposite parallel forces not acting at a point cause rotation, 4.5 describe how to investigate the stretching of rubber bands, metal wires and helical springs and display the results in graphical form,

4.6 associate the initial linear region of force-extension graphs with Hooke's law,

4.7 associate elastic behaviour with the ability of a material to recover its original shape after the forces causing deformation have been removed,

4.8 recall that the density of a substance is its mass per unit volume, understand that $\rho \ \alpha \ 1/V$ for a fixed mass of a substance, and solve elementary problems concerning density,

4.9 describe how to measure density using direct measurements of mass and volume,

4.10 recall that most substances expand as their temperature increases and that some substances expand more than others,

4.11 describe experiments to illustrate expansion,

4.12 be aware of the anomalous expansion of water and of the density changes which occur when it changes state,

4.13 solve elementary problems concerning force, area and pressure or pressure difference,

4.14 appreciate that the pressure at a point in a gas or liquid which is at rest acts equally in all directions,

4.15 understand that the pressure at a point in a gas or liquid depends on depth and on the density of the gas or liquid and use the relationship

$$\text{pressure difference} = \rho g h$$

4.16 recall that atmospheric pressure varies with height and from day to day at one place,

4.17 be familiar with the transmission of pressure by liquids, e.g., in a car jack,

4.18 make use of an understanding of the principles involved in a study of general physics to situations or to devices which may or may not be familiar.

5. Molecules and the behaviour of solids, liquids and gases

The kinetic model of matter. Solids, liquids and gases. Changes of state.
Brownian motion in gases. The random motion of gas molecules: pressure and temperature. The concept of absolute zero. The use of Celsius and Kelvin scales of temperature.
The behaviour of gases; $p \propto T$ at constant V, $V \propto T$ at constant p (Charles' law), and $p \propto 1/V$ at constant T (Boyle's law).

Candidates will be expected to:

5.1 appreciate that molecules and atoms are very small, typically 10^{-9} m to 10^{-10} m in diameter,

5.2 understand that the particles of a substance (molecules, atoms, etc.) are in a constant state of motion,

5.3 appreciate the relative spacing of, and relative forces between, particles in solids, liquids and gases,

5.4 describe qualitatively the particular structure of solids as close packed regular arrangements of bound particles, undergoing vibrations about fixed positions, 5.5 describe qualitatively the random motion of close packed liquid particles,

5.6 describe qualitatively the random motion of gas particles,

5.7 understand the changes in molecular motion associated with a change in state,

5.8 describe the behaviour of smoke particles in air (Brownian motion) and recall how to observe them experimentally,

5.9 understand the significance of Brownian motion,

5.10 explain the pressure exerted by a gas on a surface as the result of the continual bombardment of the surface by many particles,

5.11 relate qualitatively a change in temperature of a gas to a change in the average speed of its particles,

5.12 appreciate that there will be a temperature at which particulate motion ceases and relate this to the absolute zero of temperature being 0 K on the Kelvin scale,

5.13 show a qualitative understanding of the relationships between the pressure, volume and temperature of a gas and the motion of its particles,

5.14 interpret the behaviour of mechanical models simulating particle motions in 5.2 to 5.13 above,

5.15 describe how to investigate the pressure (as measured on a Bourdon gauge or equivalent) and the Celsius temperature of a fixed mass of gas at constant volume,

5.16 describe how to investigate the volume (e.g., trapped in a capillary tube) and the Celsius temperature of a fixed mass of gas at constant pressure,

5.17 describe how to investigate the pressure and volume of a fixed mass of gas at constant temperature,

5.18 interpret the results of the two experiments 5.15 and 5.16 to establish an absolute zero for temperature,

5.19 be familiar with temperature measured in kelvin and in degrees Celsius,

5.20 recall and use Boyle's law in elementary calculations,

5.21 recall and use Charles' law in elementary calculations,

5.22 make use of an understanding of the physical principles involved in a study of molecules to situations or to devices which may or may not be familiar.

6. Charge and Current

Positive and negative charge. Conductors and insulators. The use of a charge detector. (If a leaf electroscope is used no knowledge of how to charge it is expected.)

Quantity of charge; current as a rate of flow of charge. The coulomb and the ampere. Alternating current. The use of the oscilloscope. The effect of rectifying alternating current.

Potential difference as energy transfer per unit charge and as power dissipation per unit current; e.m.f. The volt and the watt.

Candidates will be expected to:

6.1 recall that electric charges are separated when certain materials are rubbed against one another, in particular that Polythene becomes negatively charged and Perspex or acetate become positively charged when rubbed with cloth,

6.2 explain the charging of objects in terms of properties of negatively charged electrons which are free to move and bound positively charged properties,

6.3 describe how equal and opposite charges can be induced on a conducting body,

6.4 appreciate that two charged objects which repel each other are similarly charged but that a charged object attracts objects which carry zero net charge as well as those which carry an opposite charge,

6.5 understand that the force between charged objects is stronger when the objects are close and when the charges are large,

6.6 describe how to distinguish experimentally between positively, negatively and uncharged bodies,

6.7 compare the relative conductive or insulative properties of a wide range of materials,

6.8 associate a current of one ampere with a flow of charge of one coulomb per second,

6.9 describe simple demonstrations to show that a flow of charge constitutes a current,

6.10 recall that a current in a metal wire consists of a flow of electrons,

6.11 recall and use the relationship $Q = It$ in simple situations,

6.12 obtain the peak value and frequency of a sinusoidal altering current from a current-time graph,

6.13 understand the effects of d.c. and a.c. in wires, filament lamps and (non-inductive) coils,

6.14 be familiar with the oscilloscope as a fast-response voltage-time graph producer,

6.15 understand the meaning of half-wave rectification,

6.16 appreciate that a volt is a joule per coulomb,

6.17 distinguish between the transfer of chemical or mechanical energy per unit charge to electrical energy in cells and generators (i.e., their e.m.f.) and the transfer of electrical energy per unit charge to internal energy or other forms of energy (i.e., a potential difference),

6.18 recall and use the relationships $W = QV$ and $P = IV$ in energy transfer calculations involving individual devices,

6.19 make use of an understanding of the physical principles involved in a study of charge and current to situations or to devices which may or may not be familiar.

7. Circuits

Current-potential difference relationships for various devices including metal wires, filament lamps and semiconducting diodes. Resistance as *V/I;* the ohm. Measurement of resistance using ammeter and voltmeter. Energy and power, the kilowatt-hour.

The simple d.c. circuit. (Any cell or battery will be treated as having negligible internal resistance.) Arrangement of resistors in series and parallel. Current conservation in circuits. Fuses.

Candidates will be expected to:

7.1 understand that a complete circuit of conducting material is necessary for there to be a steady current between the terminals of a battery of a d.c. power supply,

7.2 describe experiments to investigate the properties of individual circuit elements,

7.3 translate information about the properties of circuit elements between written, tabulated and graphical forms,

7.4 be familiar with circuit components and symbols including cells, switches, fuses, fixed and variable resistors, filament lamps, semiconducting diodes, light dependent resistors and thermistors,

7.5 draw simple circuit diagrams including those showing the correct use of ammeters and voltmeters,

7.6 recall that the current in a series circuit is the same everywhere in the circuit and that the sum of the currents in the branches of a parallel circuit is equal to the current entering the parallel section,

7.7 recall that the sum of the potential differences in a series circuit is equal to the p.d. across the whole circuit,

7.8 appreciate that ammeters have negligible resistance and that voltmeters have extremely high resistance,

7.9 recall that resistance may vary with temperature, is calculated as *V/I* and is measured in ohms,

7.10 manipulate values of current, potential difference and resistance in simple problems,

7.11 calculate power dissipation and energy consumption in simple cases, including energies quoted in kilowatt-hours,

7.12 be familiar with series and parallel arrangements of resistors,

7.13 calculate the combined resistance of two or more resistors in series and of two resistors in parallel,

7.14 appreciate the effects of length and cross-sectional area on the resistance of a conductor,

7.15 explain the principle of operation of a fuse and be able to select fuses of appropriate value for various electrical appliances,

7.16 appreciate the need for good earthing in house wiring circuits,

7.17 make use of an understanding of the physical principles involved in the study of circuits to situations or to devices which may or may not be familiar.

8. Electromagnetism

The magnetic effect of a steady current. Magnetic field lines; magnetic flux patterns for a straight wire, a circular coil and a solenoid.

Electromagnets and strong permanent magnets. (A knowledge of experimental techniques to investigate the Earth's magnetism is not expected.)

The force on a current-carrying conductor, and on a moving charged particle, in a magnetic field. Principle of measurement of direct current.

Electromagnetic induction: experiments to illustrate that cutting magnetic flux induces an e.m.f. in a circuit.

The transformer.

Candidates will be expected to:

8.1 recall that magnets repel and attract other magnets and attract magnetic substances,

8.2 know how to identify the poles of a magnetic dipole by suspending it in the Earth's magnetic field,

8.3 recall the properties of magnetically hard and soft materials,

8.4 be familiar with the use of low voltage/high current supply units for experimental work in electromagnetism,

8.5 know that an electric current in a conductor produces a magnetic field round it,

8.6 understand the terms magnetic field line or magnetic line of force and magnetic flux pattern,

8.7 sketch and recognise magnetic flux patterns for a straight wire, a flat circular coil and a solenoid, each carrying a current, and for a strong permanent dipole magnet,

8.8 understand that magnetism is induced in some materials when they are placed in a magnetic field,

8.9 describe the construction of electromagnets,

8.10 know how to use permanent magnets to produce a desired magnetic flux pattern, e.g., a uniform magnetic flux pattern over a small region,

8.11 sketch and recognise the magnetic flux pattern for a straight wire carrying a current perpendicular to a uniform magnetic field,

8.12 appreciate that there is a force on a current-carrying conductor placed in a magnetic field as long as the conductor is not parallel to the field,

8.13 appreciate that there is a force on a charged particle when it moves in a magnetic field as long as its motion is not parallel to the field,

8.14 recall that the force on a current-carrying conductor in a magnetic field increases with the strength of the field and with the current,

8.15 understand that the relative motion of a conductor and a magnetic field can cause an e.m.f. to be induced in a circuit,

8.16 describe experiments to demonstrate that induced currents increase when the rate of cutting of magnetic field lines increases, 8.17 understand that a changing magnetic flux through a circuit causes an e.m.f. to be induced in the circuit,

8.18 appreciate that electromagnetic induction is an energy transfer process,

8.19 understand that the transformer is an energy transferring device,

8.20 relate the turns ratio of an ideal transformer to the ratio of the input and output voltages,

8.21 make use of an understanding of the physical principles involved in study of electromagnetism to situations or to devices which may or may not be familiar.

9. Nuclear Physics

The nuclear model of the atom; isotopes.

The radioactive nucleus. Properties of α, β and γ radiation.

Radioactive decay as a random process; half-life.

Candidates will be expected to:

9.1 recall the relative sizes of atoms and nuclei and the relative masses and charges of electrons and nucleons,

9.2 be familiar with the nucleon number/proton number notation for an atom, e.g., $^{14}_{7}\mathrm{N}$,

9.3 understand that the emission of radioactive particles causes transmutation,

9.4 make calculations involving the changes in nucleon number and proton number resulting from the emission of given radioactive particles,

9.5 recall the nature of alpha particles, beta particles and gamma waves,

9.6 recall the range in air and other materials of the three radiations,

9.7 identify α, β and γ radiations from their penetration, ionising ability and deflection in magnetic fields,

9.8 understand the use of G-M tubes and diffusion cloud chambers to detect the radiations,

9.9 explain the meaning of half-life and appreciate the random nature of radioactive decay,

9.10 make simple deductions from tabulated and graphical data relating to a single radioactive decay process,

9.11 recall the sources of background radiation,

9.12 allow for the background radiation in handling count rates,

9.13 be aware of safety considerations related to the properties of radioactive materials, including half-life,

9.14 describe the uses to which radioactive isotopes and their radiations are put and appreciate how these uses relate to their properties,

9.15 make use of an understanding of the physical principles involved in a study of radioactivity to situations or to devices which may or may not be familiar.

10. Waves

Mechanical wave pulses. Continuous waves; wavelength, frequency, $c = f\lambda$; the hertz. Transverse and longitudinal waves.

Mechanical vibrating systems. Sound as waves. The measurement of the speed of sound in air.

The reflection, refraction and diffraction of water waves; wavefronts.

The electromagnetic spectrum treated descriptively. Wavelength of electromagnetic waves including light. The speed of electromagnetic waves.

Candidates will be expected to:

10.1 be familiar with the wave pulses and continuous waves produced on springs/slinkies and in ripple tanks and with their energy transfer properties,

10.2 interpret graphs of displacement against distance and displacement against time for both wave pulses and (sinusoidal) continuous waves,

10.3 recall and use the relationship $c = f\lambda$ for both mechanical and electromagnetic waves,

10.4 differentiate between waves which are transverse and those which are longitudinal,

10.5 understand sound as a longitudinal wave motion requiring a medium for its transmission,

10.6 recall that the loudness of a sound increases when the amplitude of vibration of the source increases,

10.7 associate the pitch of sound with the frequency of vibration of the source, e.g., a loudspeaker driven from a signal generator,

10.8 describe how to measure the speed of sound in air by a simple direct method,

10.9 draw wavefronts to illustrate the reflection, refraction and diffraction of waves,

10.10 associate refraction with a change in wave speed,

10.11 realise that the frequency of a wave does not change when its speed changes,

10.12 recall the effect of wavelength and gap size on the diffraction of waves through a gap,

10.13 recognise that mechanical resonance occurs when the natural frequency of an oscillating system is equal to the frequency at which it is being forced to vibrate,

10.14 recall the factors which determine the frequency of vibration of a stretched wire,

10.15 appreciate that a mechanical system can vibrate at more than one frequency,

10.16 list the various parts of the electromagnetic spectrum and attribute rough values to their wavelengths,

10.17 recall that all electromagnetic waves travel at the same speed in a vacuum,

10.18 describe the production and distinguishing properties of each part of the electromagnetic spectrum,

10.19 appreciate that waves from all parts of the electromagnetic spectrum transfer energy from place to place,

10.20 describe a simple experiment to detect infra-red radiation and a simple experiment to detect ultra-violet radiation, 10.21 be aware of the various applications of electromagnetic radiation of different wavelengths,

10.22 make use of an understanding of the physical principles involved in a study of waves to situations or to devices which may or may not be familiar.

11. Optics

The laws of reflection; formation of an image by a plane mirror. Refraction at a plane surface. Refractive index and its determination for glass by plotting methods. Total internal reflection. Dispersion by a prism and the formation of a spectrum.
Lenses. The formation of real and virtual images by converging and diverging lenses. (Scale ray diagrams are *not* expected.) Focal length. Linear magnification. The determination of *f* for a converging lens.

Candidates will be expected to:

11.1 appreciate that objects are seen because of the light which they give out or reflect,

11.2 represent the paths of narrow beams of light travelling in uniform media by rays,

11.3 recall that the angle of incidence equals the angle of reflection for a mirror,

11.4 construct ray diagrams to illustrate the formation of a virtual image in a plane mirror,

11.5 describe experiments to investigate the bending (refraction) of light using rectangular blocks, semi-circular blocks and prisms,

11.6 appreciate that the image of a point object is the point through which all rays from a point on the object pass or appear to pass after reflection or refraction,

11.7 recall refractive index as sin (angle in the air) divided by sin (angle in medium) where both angles are measured from the normal,

11.8 describe an experiment to determine the refractive index of glass using a glass block,

11.9 appreciate the condition for total internal reflection,

11.10 recall and use the relationship sin (critical angle) = 1/refractive index,

11.11 recall and use the relationship

refractive index = real depth/apparent depth

11.12 solve simple problems using refractive index,

11.13 be familiar with the refraction of light in everyday phenomena, e.g., the apparent depth of a swimming pool,

11.14 describe how to produce a spectrum using a prism, etc.,

11.15 appreciate the relationship between refractive index and wave speeds for light,

11.16 draw ray diagrams to illustrate the meaning of principal foci for converging and diverging lenses,

11.17 understand what is meant by the focal length of a lens and describe how to measure the focal length of a converging lens using a distant object and by a single measurement using an auxiliary plane mirror method,

11.18 describe experiments relating object and image distances to object and image sizes for converging lenses, 11.19 translate data from experiments on converging lenses from one form to another, e.g., tabulated data to graphical form,

11.20 draw ray diagrams to illustrate the formation of images by lenses, e.g., a converging lens used as a magnifying glass,

11.21 recall the construction of a simple lens camera and understand its optical properties,

11.22 make use of an understanding of the physical principles involved in a study of optics to situations or to devices which may or may not be familiar.

Textbooks and other resources

The following books may be of use to candidates studying the Ordinary Level Physics syllabus. It is not intended to suggest that a candidate should attempt to consult all of the books but rather select a few of them for study.

Edexcel is happy to receive other suggestions from teachers for books which are found to be useful, especially if such suggestions are accompanied by brief comments.

The following texts covers the entire syllabus and are suitable for use on O level courses.

Author	Title/ISBN	Publisher
Gilbert Rowell and Sydney Herbert	Physics 0-521-49585-9	Cambridge University Press Cambridge Low Price Edition Series
Stephen Pople	Complete Physics 0-19-914734-5	Oxford University Press

The following texts are useful for students although individually, do not cover the entire syllabus.

Author	Title/ISBN	Publisher
Nick England	Physics Matters 0-340-79054-7	Hodder and Stoughton 3rd edition
David Sang	Physics 0-521-77802-6	Cambridge University Press
Keith Johnson	Physics for You 0-7487-6236-1	Nelson Thornes 6th edition
Andrew McCormick and Arthur Baillie	Intermediate 2 Physics 0-340-78269-2	Hodder and Stoughton
Stephen Pople	New Coordinated Science 3rd edition Physics for Higher Tier 0-19-914822-8	Oxford University Press