GENERAL CERTIFICATE OF EDUCATION

EXAMINATION SYLLABUSES FOR 1984

PHYSICS AND ENGINEERING SCIENCE
ELECTRICITY AND ELECTRONICS

UNIVERSITY OF CAMBRIDGE LOCAL EXAMINATIONS SYNDICATE INTERNATIONAL EXAMINATIONS
June 1982
AIMS AND OBJECTIVES OF COURSE

This syllabus is intended to indicate the scope of the course and not to dictate the teacher's approach to the subject. Its character results from an attempt to provide a course which is stimulating and worthwhile, both educationally and culturally, for the variety of students who study physics at A-level. The course should be attractive and valuable to those who might take it with no expectation of using it later, as well as suitable for those for whom physics will form a major part of their studies at a university or technical college or for whom A-level physics is a necessary prerequisite for further study in some other area. The style of the syllabus represents a compromise between simply indicating the spirit of the course on the one hand and giving a detailed coverage of every topic on the other. While it may well be thought best to teach the subject 'vertically', developing the hierarchy of ideas through each particular topic in turn, there is adequate opportunity for 'horizontal' development, i.e. emphasis of the concepts which link across the topics, as the student's maturity allows. The course is successful if it imparts an increased understanding of, and fascination in, the things of the physical world around us, and if it develops the ability for thinking clearly.

The particular qualities which it is hoped that the A-level physics course will promote may be summarised as follows:

(a) knowledge of physical facts and terminology,
(b) knowledge and understanding of physical principles,
(c) the ability to understand and interpret scientific information presented in verbal, mathematical or graphical form and to translate such information from one form to another,
(d) the ability to describe phenomena in terms of models, laws and principles,
(e) the ability to formulate and perform relevant calculations,
Dimensions, including the following base quantities: mass, length, time, current, temperature, amount of substance. Application to check formulae for dimensional homogeneity.

Vector and scalar quantities. Addition and resolution of vectors.

Errors and uncertainties, simple treatment.

Dynamics. Newton's laws; mass, velocity, acceleration, momentum, force. Work. Potential energy, kinetic energy, power. $P = \frac{dW}{dx}$. Centre of mass.

Elastic collisions; conservation of momentum and energy. Inelastic collisions in one dimension only. Friction and viscous drag as forces opposing relative motion.

Circular motion. Angular velocity, Centripetal forces and accelerations.

Rotational motion. Moments and couples. Moments of inertia as $I = \frac{m}{2} r^2$. Conservation of angular momentum.

Angular momentum $I\omega$ and rotational kinetic energy $\frac{1}{2} I \omega^2$.

PHYSICS

SYLLABUS

18 Determination of c.
Knowledge of any one direct terrestrial method.

19 Conditions for interference; interference in thin films.
Limited to cases of approximately normal incidence. Wedge fringes treated quantitatively (noting possibility of phase change) and Newton’s rings treated qualitatively will suffice.

20 Diffraction of a plane wave at a wide slit with derivation of first minimum.
No treatment of resolving power of diffraction grating is required but a simple derivation of the resolving power of a telescope (optical/radio) is included: the 1.22 factor for a circular aperture may be assumed.

21 Production, detection and components of plane-polarised e.m. waves.
For light, production by polaroid and by reflection (Brewster’s law not required): for radio, production by dipole aerial. Quantitative effect of rotation of polaroid or dipole aerial on plane-polarised radiation is included.

22 Quantisation of radiation; photoelectric effect and the Einstein relation; photons.
An example of wave-particle duality.

23 Rectilinear propagation.
Limiting case of diffraction when apertures are much greater than wavelengths, justifying ray treatments.

24 Refraction and its explanation in terms of speeds; refractive index, Snell’s law.
Critical angle and total internal reflection is assumed to have been treated at O-level.

25 Mirrors and lenses as image-forming devices. Focal length and use of the relation between \( u, v, f \).

26 Simple astronomical telescope in normal adjustment and simple two-lens microscope in normal adjustment.

27 Spectrometer as collimator, diffraction grating and telescope.
Simple treatment of angular magnification is included.

28 Electromagnetism
Details of mechanical adjustment of spectrometer are not required.

29 Steady currents. Sources of current. Effects of current.
No details of cells are required.

30 Force between current-carrying conductors; the ampere, \( \mu \); the coulomb.
It should be appreciated that the definition of the ampere is equivalent to fixing the value \( \mu \) as \( 4\pi \times 10^{-7} \) \( \text{H} \) \( \text{m}^{-1} \).

31 Potential difference as power dissipated/current; the volt. Calibration of voltmeter by an electrical heating method. E.M.F.
Calibration of voltmeter necessary in order to relate the volt to mechanical units (\( V = W \ A^{-1} \) or \( J \ C^{-1} \)), a specific heat capacity by mechanical means being assumed.

32 Resistance, \( R = \frac{V}{I} \); \( \frac{1}{V} \) relationships for materials in linear and non-linear cases, including diodes; Ohm’s law as a special case.
The Lorenz method for resistance is not required.

33 Nature of charge carriers in metals, semi-conductors and electrolytes. Quantitative relationship between current \( I \), current density \( J \), cross-sectional area \( A \) and drift velocity \( v \) in single carrier systems. Interpretation of drift velocity in terms of mean time \( \tau \) between collisions,\( \tau = \frac{E}{n \sigma /2m} \);
In these formulae, \( e \) is the charge on the carrier, \( E \) is the electric field, \( n \) is the number of carriers per unit volume, \( \tau \) is the mean time between collisions.

34 Temperature dependence of resistance in metals.
Temperature dependence of resistance in semiconductors including simple idea of temperature dependence of carrier concentration in intrinsic semiconductors.

35 Simple d.c. circuits, Kirchhoff’s laws, series and parallel combinations.
Simple network calculations. Derivation and formulae for resistors in series and parallel is included.

36 Potentiometer and the basic Wheatstone bridge circuit; use of standard resistors and standard cells.
For the measurement of currents and of small e.m.f.s, e.g. thermoelectric e.m.f.s., for the comparison of cell e.m.f.s. and of resistances. See note 78. Familiarity with slide wire bridges and potentiometers is expected.

37 Internal resistance of sources.
The existence of internal resistance in sources and its simple consequences for external circuits.

38 Use of shunts and series resistors in ammeters and voltmeters.
PHYSICS

SYLLABUS

39 Electromagnetics. Magnetic flux density defined by
\[ B = \frac{F}{I} \cos \theta \]. Force on moving charge in a magnetic field.

40 Simple cases of the motion of charged particles in electric and magnetic fields.

41 The Hall effect. Its use in semiconductors to measure \( B \). Questions requiring the formal definition of the Hall coefficient will not be set.

42 Measurement of \( e/m \) and \( v \) for electrons and ions.

43 The cathode-ray tube. Basic structure of oscilloscope to include the electron gun, deflecting and display systems, time base and external circuit connections: details of time base and amplifier circuitry are not required. Uses of the oscilloscope for measurement and display. It is expected that appropriate use will be made of the oscilloscope at various points of the course.

44 Couple on rectangular coil in uniform field; the moving-coil galvanometer.

45 Ballistic use of galvanometers.

46 Field near a long straight wire, at centre of circular coil, inside and at the end of a long straight solenoid.

47 Force between long, straight, parallel current-carrying conductors.

48 Magnetic medium filling the whole space; permeability \( \mu \), relative permeability \( \mu_r \).

49 Qualitative description of fields of permanent and electromagnets.

50 Magnetic flux \( \Phi = BA \).

51 Induced e.m.f.; Faraday’s and Lenz’s laws.

NOTES

52 Measurement and comparison of flux densities. By force on a current-carrying conductor, search coil with indicator, Hall effect. (See topics 40 and 41).

53 Mutual and self-inductance, the henry. Energy stored in an inductor carrying a current, \( \frac{1}{2}LI^2 \).

54 Simple a.c. and d.c. generators, and d.c. motors.


56 Coulomb’s law, \( k \).

57 Concept of electrical field, \( E = F/Q \).

58 Electric potential; the relationship \( E = -\frac{dV}{dx} \).

59 Dielectric medium filling the whole space; permittivity \( \varepsilon \), relative permittivity \( \varepsilon_r \).

60 \( E \) and \( V \) near point charges and surfaces.

61 Principle of Van de Graaff machine.

62 Capacitance, \( C = Q/V \), the farad.

63 Measurement and comparison of capacitors. Measurement by vibrating switch method or by comparison by means of a ballistic galvanometer will suffice.
Syllabus

64 Charge and discharge of capacitors through resistors including time dependence \( \exp(-t/\tau) \) with time constant, \( \tau = RC \).

65 Energy of charged capacitor, \( \frac{1}{2} CV^2 \).

66 Series and parallel connection.

67 Parallel plate capacitor. Determination of \( \varepsilon_0 \).

68 Relation of \( \varepsilon_0 \mu_0 \) to \( c \).

69 Alternating currents: frequency, phase and amplitude; peak and r.m.s. values; their relation in the sinusoidal case.

70 Energy and power in resistive loads.

71 Alternating e.m.f.'s applied to resistors, capacitors and inductors separately; phase lag and lead.

72 Phasor representation and addition of alternating quantities, exemplified by quantitative treatment of resistor and capacitor in series.

73 Ideal transformer.

74 Resonant circuits: quantitative treatment of resonant frequency of parallel L-C circuit without resistance; qualitative discussion of effect of damping.

75 Electronics. Diode as circuit element; rectification and capacitor smoothing; use in a.c. instruments.

Notes

64 Proof is not required.

66 Derivation of formulae for capacitors in series and parallel is included.

67 Derivation of capacitance. Determination of \( \varepsilon_0 \) by direct measurement of capacitance of capacitor of known dimensions, e.g. vibrating switch method.

68 Proof of relation is not required.

70 Calculation of reactance.

71 Impedance as summation of resistance and reactance.

73 An experimental approach and reference to principle of conservation of energy are expected.

74 \( pV/T \) is a consequence of adopting the gas scale.

75 Internal energy, work and heat, and first law of thermodynamics.

76 Method of determining \( C_v \) for a gas is not required.

77 Centigrade scales defined in terms of \( t^{\circ}C = 100 \times (t - 273.15) / (273.15 - 273) \) where \( x \) represents any thermometric property.

78 Simple potentiometric and bridge circuits (with brief qualitative reference to compensating leads) will suffice.

79 The term thermodynamics is introduced because of its occurrence in the SI definition of the kelvin but understanding of the significance of the term is not expected. Brief reference should be made to the triple point of water as an invariant.

80 Boyle's law.

81 Isothermal and adiabatic changes in a perfect gas; work done in expansion, principal molar heat capacities:

\[
C_p - C_v = R, \quad C_p/C_v = \gamma
\]

82 Proof of \( pV/T \) is not required.

83 Qualitative understanding of mechanisms of conduction in metals and non-metals (electron diffusion, lattice vibration).

86 The principles of methods of determining thermal conductivity for good and bad conductors.
PHYSICS

Thermal radiation as a form of energy.

Principle of simple resistance bolometer.

Prévost's theory of exchanges.

Qualitative effect of nature of surface on energy absorbed or emitted by it; black-body radiation.

Stefan's law.

Wien's displacement law.

Distribution of energy in spectrum of black-body radiation; relation to the electromagnetic spectrum.

E Microscopic Physics

de Broglie's relation. The phenomenon of electron diffraction.

Measurement of $h$.

Atomic structure. Evidence from x-particle scattering experiments.

Quantisation and simple ideas of energy levels in atoms. Excitation and ionisation energies. Emission and absorption spectra and explanation in terms of energy levels.

X-ray spectra; principle of generation of X-rays. Maximum frequency for given tube potential.

The atomic nucleus: neutrons and protons.

$E = mc^2$, mass excess and nuclear binding energy.

Charge and mass of nuclei; principles of mass spectrometry.

Proof is not required.

Simple understanding that some properties of electrons require wave treatment. An example of wave-particle duality.

A simple treatment neglecting upthrust from air will suffice.

Deduction of the existence of energy levels from line spectra will suffice; knowledge of the Franck-Hertz experiment is not required.

Details of X-ray tubes as such are not required. Consideration should be given to both the continuous spectrum and the characteristic line spectrum. The effect of atomic number on the characteristic wavelengths is included but a formal treatment of Moseley's law is not required.

It should be understood that energy and mass are not interconvertible. Energy has mass, the mass of energy $E$ being given by $E/c^2$. Hence, energy is always conserved and mass is always conserved.

Syllabus

101

Atomic number, relative atomic mass, isotopes.

Radioactivity, random nature; decay law, use of exponential form, decay constant and half-life.

Nature of $\alpha$, $\beta$ and $\gamma$ rays.

Detection of ionising radiations: cloud chamber, Geiger-Müller tube, solid state detector.

Nuclear reactions: conservation of atomic number, mass number, energy and mass in simple reactions and in radioactive decay; nuclear energy.

Uses of radioactive isotopes.

Kinetic theory. Evidence for belief in molecules.

Microscopic model of ideal gas and derivation of $p = \frac{4\pi m}{3} \langle c^2 \rangle = \frac{4}{3} \rho \langle c^2 \rangle$ leading to $pV = \frac{3}{2} M \langle c^2 \rangle = \frac{3}{2} RT$.

The Boltzmann constant. Law of equi-partition of energy, degrees of freedom and the effect of their number on value of $\gamma$.

Distribution of molecular speeds.

Principles of an experimental method of determining distribution is included. Knowledge of the general form of the distribution graph and the effect of temperature changes on its form will suffice.

Interatomic forces. The form of interatomic force and potential curves and their interrelation.

The condensed states.

Principles only of separation of isotopes by centrifuge and mass-spectrometer.

Fission of $^{235}\text{U}$ by thermal neutrons. Technical details of reactor piles are not required. The balancing of nuclear equations by application of conservation laws is included.

It is expected that candidates will have a reasonable knowledge of two applications, one biological and one non-biological, rather than superficial knowledge of several applications.

Integration over angles is not required but the inadequacy of simpler treatments should be pointed out. Note the use of $\langle \ldots \rangle$ to indicate mean value.

Qualitative reference to the possibility of the suppression of certain degrees of freedom is included.
PHYSICS

114. X-ray diffraction by crystals; Bragg’s law and Bragg angle.

Use of X-ray diffraction to determine layer separation is included.

115. Elasticity of solids, Hooke’s law as linear approximation for small displacements, the Young modulus and its determination.

Experimental determination of the Young modulus for wires only. Significance of small value of maximum stress (approx. 0.1% in relation to the interatomic force curve, see 113.

116. Qualitative understanding of origin of thermal expansion.

117. Phenomena in extension of a wire beyond elastic limit.

A qualitative explanation taking account of dislocation movement is intended.

118. Work done in extension.

119. Change of state, origin of latent heats: principles of methods of determining of latent heats.

Mathematical Needs

Essential Requirements (N.B. A substantial part of the following is covered in most Mathematics courses up to O-level. Candidates not taking Mathematics at A-level will require special provision of Mathematics teaching during the A-level Physics course and cannot be expected to cope properly with the Physics syllabus without such provision.)

Make calculations involving addition, subtraction, multiplication and division of quantities expressed in decimal notation.

Make approximate evaluations of numerical expressions, using approximations such as \( \pi \approx 3 \).

Express small fractional changes as percentages, and vice versa.

Calculate an arithmetic mean.

Transform decimal notation to power of ten notation (standard form), and carry out calculations in standard form.

Use tables or calculators for evaluating squares, square roots, reciprocals, sines, cosines and tangents.

Multiply and divide using a calculator, logarithm tables or a slide rule.

Change the subject of an equation. Most such equations involve only the simpler operations, but do include positive and negative indices and square roots.

Substitute physical quantities into physical equations using consistent units so as to calculate one quantity. Check the dimensional consistency of such equations.

Solve simple algebraic equations. Most are linear, but they include equations involving inverse and inverse square relationships, and simultaneous equations.

Formulate simple algebraic equations as mathematical models of physical situations and identify failures of such models (applications include dynamics, electric circuits and kinetic theory).

PHYSICS

33

Recognise the equivalent forms of the logarithms of each of \( ab, a/b, x^a \) and \( e^{ax} \) and be able to interconvert \( \ln x \) and \( 1g x \).

Recall and use in the context of error estimation and other simple applications the expansions to one term in \( x \) of numerical instances of the form \( (1 \pm x)^n \), where \( n \) may be negative or fractional, but \( 0 < x < 1 \). (Note \( < \) very much less than).

Comprehend and use the symbols

\[ <, >, <, >, \approx, \equiv, /, \propto, \text{and} \langle x \rangle \text{ (for mean value of} \ x \rangle) \]

Test tabulated pairs of values for direct proportionality, by a graphical method, or by constancy of ratio.

Geometry and Trigonometry

Calculate areas of right-angled and isosceles triangles, circumference and area of circles, areas and volumes of rectangular blocks, cylinders and spheres.

Identify simple shapes with areas that are approximate to those of more complex shapes (namely narrow triangles and areas of strips in integration).

Recognise applications of simple theorems: Pythagoras’ theorem with application to the chord theorem for a diameter and a perpendicular chord, congruency and similarity of triangles, angle sum of triangle.

Use sines, cosines and tangents in problems; recall or quickly calculate values at \( 0^\circ, 30^\circ, 45^\circ, 60^\circ, 90^\circ, 180^\circ \).

Translate from degree to radian measure, and vice versa.

Use radian measure particularly in connection with trigonometric functions.

Recognise and sketch graphs of \( \sin \theta, \cos \theta \).

Use the identity \( \sin^2 \theta + \cos^2 \theta = 1 \).

Recall \( \sin \theta = \theta, \cos \theta \approx 1, \tan \theta = \theta \) for small \( \theta \).

Sketch graphs of harmonically varying quantities, e.g. \( \sin (\omega t) + \cos (2\omega t) \) or \( \sin (\omega t + \pi/2) + \cos (2\omega t + \pi/2) \).

Vectors

Find the resultant of two vectors, recognising situations where vector addition is appropriate.

Obtain expressions for components of vectors in perpendicular directions recognising situations where vector resolution is appropriate.

Graphs

Translate information between graphical, numerical, algebraic and verbal forms.

Select appropriate variables and scales for graph plotting.

Determine the slope and intercept of a linear graph, in physical units.

Choose by inspection a straight line which will serve as the ‘least bad’ linear model for a set of data presented graphically.

Recall the form \( y = mx + c \).

Use logarithmic plots to test exponential and power law variations.

Sketch and recognise the forms of curves such that \( y \propto 1/x, y \propto x, y \propto 1/x^3 \).

Understand and use the slope of a tangent to a curve as a measure of rate of change.

Understand and use the area ‘below’ a curve where the area has physical significance.

Calculus

Use natural logarithms in arithmetic calculations and algebraic manipulations of simple kinds.
Correctly combine absolute and fractional errors in simple error estimations.

Use the notations: \( (\text{identity}) \), \( \Sigma, f, d/dr, d^2/dr^2 \), \( x \) and \( \langle x \rangle \) (mean value), \( f(x), \delta x, \Delta x \) (finite increment), \( \delta x \) (small increment), \( \ln x \rightarrow 0 \rightarrow \infty \).

Use first and second derivatives in solving physical problems, usually involving only simple polynomials, trigonometric functions and the exponential function.

Construct equations of the form \( dy/dx = ky \) and \( d^2y/dx^2 = -k^2y \) as mathematical models of physical situations, and solve in particular cases.

Use the relationship between the derivative and the slope of a curve, including the features of maxima and minima.

Appreciate the relationship between the definite integral as the area ‘below’ a curve, and integration as the reverse of differentiation.

Use the forms of the integrals \( x^n \) (including the special case of \( n = -1 \)), \( \sin \theta, \cos \theta \).

**Numerical Calculation**

Be able to estimate errors in numerical work.

Be able to handle numerical work so that significant figures are neither lost unnecessarily nor carried beyond what is justified.

Be able to estimate orders of magnitude, both in numerical work and from a knowledge of science.

**Summary of key quantities**

Candidates will be expected to be familiar with the following quantities, their symbols, their units and their interrelationships. They should also be able to carry out calculations and deal with questions involving them along the lines indicated in the detailed syllabus. The list should not be considered exhaustive.

<table>
<thead>
<tr>
<th>Quantity</th>
<th>usual symbols</th>
<th>usual unit</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Base quantities</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>mass</td>
<td>( m )</td>
<td>kg</td>
</tr>
<tr>
<td>length</td>
<td>( l )</td>
<td>m</td>
</tr>
<tr>
<td>time</td>
<td>( t )</td>
<td>s</td>
</tr>
<tr>
<td>electric current</td>
<td>( I )</td>
<td>A</td>
</tr>
<tr>
<td>thermodynamic temperature</td>
<td>( T )</td>
<td>K</td>
</tr>
<tr>
<td>amount of substance</td>
<td>( n )</td>
<td>mol</td>
</tr>
<tr>
<td><strong>Other quantities</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>temperature</td>
<td>( t, \theta )</td>
<td>°C</td>
</tr>
<tr>
<td>area</td>
<td>( A, S )</td>
<td>m²</td>
</tr>
<tr>
<td>volume</td>
<td>( V, v )</td>
<td>m³</td>
</tr>
<tr>
<td>density</td>
<td>( \rho )</td>
<td>kg m⁻³</td>
</tr>
<tr>
<td>velocity</td>
<td>( u, v, w, \dot{x}, \ldots )</td>
<td>m s⁻¹</td>
</tr>
<tr>
<td>acceleration</td>
<td>( a, \ddot{x}, \ldots )</td>
<td>m s⁻²</td>
</tr>
<tr>
<td>acceleration of free fall force</td>
<td>( g )</td>
<td>m s⁻²</td>
</tr>
<tr>
<td>work, energy</td>
<td>( W, E, U )</td>
<td>J</td>
</tr>
<tr>
<td>potential energy</td>
<td>( V, \Phi, E )</td>
<td>J</td>
</tr>
<tr>
<td>kinetic energy</td>
<td>( T, K, E_k )</td>
<td>J</td>
</tr>
<tr>
<td>power</td>
<td>( P )</td>
<td>W</td>
</tr>
<tr>
<td>torque</td>
<td>( T )</td>
<td>N m</td>
</tr>
<tr>
<td>pressure</td>
<td>( p )</td>
<td>Pa</td>
</tr>
<tr>
<td>momentum</td>
<td>( I )</td>
<td>kg m s⁻¹</td>
</tr>
<tr>
<td>moment of inertia</td>
<td>( \omega, \Omega, \theta )</td>
<td>rad s⁻¹</td>
</tr>
<tr>
<td>angular acceleration</td>
<td>( \omega, \theta )</td>
<td>rad s⁻¹</td>
</tr>
</tbody>
</table>

\begin{aligned}
\text{angular momentum} & = p_x b, l \\
\text{gravitational constant} & = G \\
\text{gravitational field} & = g \\
\text{gravitational potential} & = \Phi \\
\text{period} & = T \\
\text{frequency} & = f, \nu \\
\text{angular frequency (2\pi/}) & = \omega \\
\text{wavelength} & = \lambda \\
\text{refractive index} & = n \\
\text{speed of electromagnetic waves} & = c \\
\text{Young modulus} & = E \\
\text{tension} & = T \\
\text{normal stress} & = \sigma \\
\text{Planck constant} & = h, = h/2\pi \\
\text{work function} & = \Phi \\
\text{critical angle} & = \theta_c \\
\text{focal length} & = f \\
\text{object distance} & = u \\
\text{image distance} & = v \\
\text{magnifying power} & = M \\
\text{electric charge} & = Q \\
\text{electric potential} & = V, \varphi \\
\text{electric potential difference} & = \Delta V \\
\text{electromotive force} & = E \\
\text{resistance} & = R \\
\text{resistivity} & = \rho \\
\text{conductance} & = G \\
\text{conductivity} & = \sigma \\
\text{current density} & = J, j \\
\text{magnetic flux density} & = B \\
\text{Hall coefficient} & = R_H \\
\text{specific charge} & = q \\
\text{permeability} & = \mu \\
\text{permeability of free space} & = \mu_0 \\
\text{relative permeability} & = \mu_r \\
\text{magnetic flux} & = M, L_{zz} \\
\text{mutual inductance} & = L \\
\text{self-inductance} & = L \\
\text{permittivity} & = \varepsilon \\
\text{permittivity of free space} & = \varepsilon_0 \\
\text{relative permittivity} & = \varepsilon_r \\
\text{electric field strength} & = E \\
\text{capacitance} & = C \\
\text{time constant} & = \tau \\
\text{reactance} & = X \\
\text{impedance} & = Z \\
\text{molar gas constant} & = R \\
\text{heat capacity} & = C \\
\text{specific heat capacity} & = C \\
\text{molar heat capacity} & = C_m \\
\text{principal molar heat capacities} & = C_p, m \\
\text{ratio of principal heat capacities} & = \gamma \\
\text{thermal conductivity} & = k \\
\text{Stefan constant} & = \sigma \\
\text{activity of radioactive source} & = A \\
\text{decay constant} & = \lambda \\
\end{aligned}
The syllabus in setting experiments; where necessary, candidates will be told exactly what to do, only knowledge of theory within the syllabus being demanded.

In addition to points that may be specified in the question paper, the examiners will look for competence in the following respects: correct reading of scales, including estimation of fractions of a graduation in both linear and angular measure; recognition of circumstances where a very approximate determination of some quantity is adequate for the purposes of the experiment and the seeking of further accuracy would be a waste of time; appreciation of the possible value of a quick rough preliminary survey of the experiment to locate the most fruitful range for more detailed and careful measurements: the recording of check and repeat readings when made and the listing of any other precautions taken, showing an understanding of their importance.

Examiners will not expect candidates to calculate errors by statistical methods, but will expect them to show a common-sense appreciation of orders of accuracy, e.g. by refraining from expressing their readings and results to more figures than can be significant. Candidates will be expected to record their data clearly, in tabular form where appropriate, and may be asked to display their measurements in the form of a graph which provides a clear and suitable record of these and from which information can readily be extracted.

Questions requiring the use of a balance will not be set.

The rubrics of the Practical Examination papers include the following.

'Answer Question 1 and one other question.

Candidates will not be allowed to use the apparatus or write for the first fifteen minutes.

Mathematical tables, including reciprocals, are available.'

Candidates are expected to record on their script all their observations as soon as these observations are made, and to plan the presentation of the records so that it is not necessary to make a fair copy of them. The working of the answers is to be handed in.

Details on the question paper should not be repeated in the answer, nor is the theory of the experiment required unless specifically asked for. Candidates should, however, record any special precautions they take and any particular features of their method of going about the experiment.

Marks are given mainly for a clear record of the observations actually made, for their suitability and accuracy, and for the use made of them.

 Provision has been made in the question paper for you to record your observations and readings and for you to plot the graphs required. Additional answer paper and graphs should only be submitted if it becomes necessary to do so.

Particular attention is directed to the fourth paragraph of the rubric.

The attention of teachers is also drawn to Circular to Schools No. 78/20 dated October 1978.

The scheme is available for school candidates in the U.K. who are taking Physics at Advanced Level. All candidates must still take the normal Practical Physics examination.

It is recognised that only a minority of schools may wish, or be able, to take advantage of the scheme. It is intended that candidates should take part in the scheme on a voluntary basis, with the agreement of the school staff, and that they should be free to suggest studies in accordance with their own particular interests in these subjects and with the facilities available.

Each school with candidates wishing to offer individual studies must send to the Syndicate for approval, on forms E39 which will be provided on request, as precise a statement as possible of what each candidate proposes to do; broad titles conveying only a vague idea of what is intended should be avoided. The forms should be returned to the Syndicate by 1 November in the year preceding that in which the candidates will sit the Advanced Level examination. Provisional entries must be submitted on form E40 by 20 January in the year of examination and final entries confirmed on the school entry form submitted by 1 March.

It is expected that work on any study submitted for assessment will extend over about three or four terms. It is also recommended that, preceding work on individual studies, the candidates will preferably have taken part in a straightforward group investigation in order to gain practice in the planning and writing up of an individual study.

Wherever possible, candidates should work individually on their studies but, if circumstances make it necessary for pairs of candidates to share apparatus and do some of their experimental work together, separate accounts of the work done must be prepared independently by each candidate and should include statements of their individual contributions.

The school will be required to send to the Examiner the candidates' individual accounts of their work, by 31 March in the year of the examination. For easy
reference, candidates must include a table of contents, and the pages must be numbered. Candidates should write on one side of the paper only, leaving a margin on each page. Each account should contain a bibliography and appropriate acknowledgments of all external help.

The Examiner will visit each school concerned, on dates mutually arranged, and will interview each candidate separately (for approximately 15 min). The apparatus that has been used by the candidates must be available in working order during the Examiner’s visit.

The Examiner will make his assessments on the basis of the written accounts and the interviews and will take into consideration any original contribution which the candidate may have made to the design or construction of the apparatus. In particular, the Examiner will look for a precise statement of what the candidate set out to investigate, the understanding of essential physical principles, the ability to give a clear and concise account of work carried out, and evidence of judgement in deciding what, if anything, has been established at various stages of the investigation.

If a school wishes the candidates’ written material to be returned to the school earlier than September in the year of the examination, written application should be made by 15 July.

It is appreciated that the candidate’s original aim may prove too ambitious or otherwise unrealistic and that the work finally submitted may not exactly match the original outline description. For instance, preliminary work on the study may raise points of interest which it seems more profitable to pursue and which may deflect the candidate into channels not directly contributing to his original aim. This will not necessarily count against the candidate since an intelligent study of the cause of some apparently anomalous findings may prove more worthwhile than the sustained pursuit of the original aim at the expense of leaving a number of experimental results unexplained.

Bonus marks will be awarded and the following conditions will apply:
(a) bonus marks will not be taken into account in fixing the pass mark for the subject;
(b) the maximum benefit gained by any one candidate will be to raise his subject result by one grade.

An additional fee per candidate will be charged, which should be included with fees for other Advanced Level subjects.