CAMBRIDGE
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A Level

Physics

Session: 1974
Type: Syllabus
Code: 861

PHYSICS (861)

(May not be taken with Physical Science.)

The syllabus must be taken to include the syllabus for Ordinary Level Physics. No knowledge beyond that required for Ordinary Level will be expected about topics which are not specifically mentioned in the Advanced Level Syllabus.

The syllabus is not intended to suggest a teaching order. There is no extended syllabus for candidates taking the Special Paper in Physics, but the questions set in the Special Paper may be expected to provide a more searching test for these candidates.

SI nomenclature and units will be used in all question papers. (See Circular S32A, June 1969.)

Familiarity with the use of a slide rule is expected.

ARRANGEMENT OF PAPERS

At Advanced Level there will be two 2½-hour theory papers (Paper 1 and Paper 2) and a 3-hour Practical Test. The Practical Test will carry one-quarter of the total marks for the subject.

Papers 1 and 2 will each contain ten questions. Each paper will be divided into three sections and candidates will be required to answer five questions, including one from each section, in each paper. The sections will not necessarily be defined by the traditional divisions of the subject, e.g. Heat, Light, but questions on any topic may appear in any section. In both papers questions will be set on Part 3 of the syllabus.

In the Practical Test, three questions will be set, one of which will be a compulsory question. Candidates will be required to answer two questions (see p. 25).

The Special Paper will be a 2½-hour paper containing ten questions of which candidates will be required to answer any five.

DETAILED SYLLABUS

PART 1

SYLLABUS	NOTES
General introductory items	
1. Aids to measurement.	Micrometer, vernier, etc.
2. Dimensions of physical quantities.	For checking equations, not for derivation of formulae.
3. Motion in a straight line.	Equations of uniformly accelerated motion in a straight line. Graphical methods. Simple determination of g by free fall method. Non-uniform acceleration, including use of graphical methods.
Motion of projectiles.	Simple cases.
Mechanics and properties of matter	
4. Composition and resolution of vectors.	Particular application to velocities, forces, and momentum.
5. Moments, couples.	
6. Newton's laws of motion. Gravity (see also item 11).	Mass and weight. Centre of gravity.
7. Conservation of linear momentum.	Collisions, with special reference to the use of the laws of conservation of momentum and energy. Questions will not be set on oblique collisions or on the use of the coefficient of restitution.
8. Static and kinetic friction.	General ideas of laws of friction. Simple determination of a coefficient.
9. Work, W. Kinetic energy, T and potential energy, V. Power, P.	Potential energy of interacting bodies. Work represented by area under a force-distance graph. Translational and rotational kinetic energy.
10. Uniform motion in a circle. Centripetal acceleration and centripetal force.	Practical examples.
11. Planetary motion. Newton's law of gravitation.	Kepler's laws. Relation between G and g. Principle of a laboratory determination of G. Gravitational potential energy.
12. Simple harmonic motion.	Experimental and mathematical treatment. Examples such as simple pendulum and light helical spring. Determination of g. Questions will not be set on the compound pendulum.
13. Fluid pressure. Upthrust. Archimedes' principal.	Pressure at a point in a fluid. Applications: flotation, determination of density and relative density. Natural convection.
14. Motion in fluids.	Qualitative treatment of viscous drag, terminal velocity, streamline flow, turbulence. Bernouilli effect, illustrated experimentally.

SYLLABUS	NOTES
15. Elasticity.	Hooke's law. Young's modulus, E, and its determination. Elastic limit. Limit of proportionality. Yield point and breaking point. Work done in extension and compression.
16. Surface tension (free surface energy).	Simple phenomena, including angle of contact. Capillary rise. Pressure difference across a spherical surface.
Optics (Either wave or ray treatment is acceptable, where applicable, in this section.)	
17. Reflection and refraction at a boundary.	Reflection and refraction at plane surfaces. Refractive index, critical angle, total internal reflection.
18. Refraction through a prism.	Formula for deviation through a thin prism for small angles of incidence, including derivation of the formula.
Minimum deviation.	Formula connecting minimum deviation and refractive index, including derivation of the formula.
Spectrometer.	Emission spectra, line and continuous. Absorption spectra.
19. Spherical mirrors and thin lenses.	Simple experiments with mirrors and lenses.
Relations between u, v, f and r for mirrors; u, v and f for thin lenses, and f as a function of refractive index and radii of curvature for thin lenses. Focal length of thin lenses in contact.	Derivation and use of these relations. Questions on refraction at single spherical surfaces will not be set. No questions will be set involving any particular sign convention.
Spherical aberration and chromatic aberration.	Simple qualitative consideration, including experimental demonstration. (Spherical aberration only in relation to a point source on the axis of a large aperture lens or mirror.)
Paraboloidal mirror.	
20. Microscope and telescope (refracting and reflecting).	Magnification and magnifying power. Methods of obtaining erect images, including prism binoculars. Questions will not be set involving achromatic or other compound eyepieces and objectives.
Essential features of camera and projection lantern.	
Oscillations and waves and related phenomena	
21. Free, damped, and forced oscillations. Resonance.	To be treated qualitatively by means of demonstrations and graphs and by using mechanical and electrical illustrations.
Harmonics.	Influence on quality of sound.
22. Waves — properties of waves. Types of wave — transverse, longitudinal; progressive, stationary. Reflection and refraction of waves.	In relation to electromagnetic, sound, and water waves. Relation between velocity, v, frequency, f, and wavelength, λ. Experimental determination of velocity of sound in free air and in a tube. Determination of frequency of sound waves.

SYLLABUS	NOTES
Superposition of waves. Interference and beats. Doppler effect.	In sound and electromagnetic waves.
23. Wave aspect of electromagnetic radiation. Wave theory as applied to reflection and refraction at a plane surface. Velocity of light, c, by a terrestrial method.	
Double slit type of interference.	Qualitative and quantitative.
Simple treatment of plane transmission grating.	Its use for measuring wavelengths.
Other simple interference phenomena.	Including a qualitative treatment of interference in thin films.
24. Diffraction.	The phenomenon of diffraction treated qualitatively.
25. Polarization. Production and detection of plane-polarized light.	Details of Nicol prism will not be asked.
Polarization of radio waves.	Reference to dipole aerial as emitter and receiver.
Heat	
26. Temperature. Scales of temperature.	Definition in terms of a physical property.
Types of thermometer.	Liquid in glass, constant volume (simple type), resistance, thermoelectric. Pyrometers.
27. The joule as a unit of both work and heat.	
Specific heat capacity, change of state, specific latent heat.	Electrical methods including constant flow method; method of mixtures. Accurate determination of the specific heat capacity of water.
The molecular theory of matter	
28. Evidence for the belief in the existence of molecules.	Brownian motion. (No calculations will be set.)
Qualitative treatment of various phenomena in terms of the kinetic theory.	E.g. surface tension, evaporation, latent heat, saturated and unsaturated vapours.
Determination of saturated vapour pressure.	
29. Boyle's law.	Experimental verification.
Absolute temperature. Gas equation $\frac{PV}{T}$ = constant. Dalton's law of partial pressures.	
30. Kinetic theory of ideal gases.	Derivation of $p = \frac{1}{3}\rho\overline{c^2}$.
Real gases.	Inadequacy of simple assumptions of kinetic theory (qualitative only). Critical temperature.

SYLLABUS	NOTES
31. Principal specific heat capacities of a gas.	Questions will not be set on experimental determination.
Difference of specific heat capacities ($C_p - C_v$) and its relation to the gas constant.	Derivation of this relation.
Isothermal and adiabatic changes. The relation pv^γ = constant.	Proof of the relation will not be required.

Transference of heat energy

SYLLABUS	NOTES
32. Quantitative consideration of thermal conduction.	For cases of parallel flow only.
Coefficient of thermal conductivity and its determination.	For good and bad solid conductors—principle of one method for each.
33. Radiation as a form of energy.	Use of **either** thermopile **or** bolometer for detection of radiation.
Effect of nature of surface on energy radiated and absorbed by it. Black-body radiation. Stefan's law.	
Distribution of energy in the spectrum of black-body radiation.	Form of spectral curves.
Ultra-violet (u.v.) and infra-red (i.r.) radiation. The complete electromagnetic spectrum.	Properties and methods of detection of these radiations.

Survey of energy

SYLLABUS	NOTES
34. Conversion of energy, *E*, from one form to another.	Gravitational, mechanical (kinetic and potential), thermal, electrical, magnetic, radiant, chemical. (See also item 59).
Conservation of energy. Degradation of other forms of energy into thermal energy.	

PART 2

Current, charge, potential difference, power

SYLLABUS	NOTES
35. The ampere, A.	
Conservation of current at a junction.	Treated as axiomatic.
Definition of unit charge, *Q*. The coulomb, C.	
E.M.F.: potential difference. The volt, V.	
Power.	
Electrical energy: kilowatt-hour, kWh.	
Inter-conversion of electrical energy with other forms.	Quantitative treatment.

Circuits

SYLLABUS	NOTES
36. General variation of current with p.d. in solids, liquids and gases.	Including thermionic devices, ionized gases, and non-linear resistors.
Extension of Ohm's law to combinations of resistors and to a complete circuit.	
Resistivity, ρ.	
Temperature coefficient of resistance.	
37. Potentiometer.	Theory of the potentiometer. Application to the measurement of p.d. (including thermo-electric e.m.f.), current and resistance.
Wheatstone bridge.	Theory of the circuit and use of the simple Wheatstone bridge circuit for comparison of resistances. Questions will not be asked on modifications of the Wheatstone network for finding battery resistance, galvanometer resistance, or resistance of an electrolyte.

Magnetism

SYLLABUS	NOTES
38. The idea of magnetic field. Magnetic flux density (or magnetic induction) *B*. Magnetic flux (or flux of magnetic induction) ϕ.	Treatments involving magnetic field intensity (magnetizing force) *H* will be acceptable but questions specifically requiring this concept will not be set.
Permeability. Relative permeability.	Questions will not be set on the experimental determination of permeability.
39. Experimental determination of magnetic flux ϕ and of magnetic flux density *B* by any one method.	E.g. by means of an induced e.m.f. or by calibrated ballistic galvanometer (or fluxmeter) and search coil, or by force on a current.
40. The earth's magnetic field.	Qualitative treatment, including the ideas of variation (declination) and dip.
Superposition of magnetic fields. Compass-needle as indicator of direction of the resultant.	
Deflection magnetometer as a means of comparing the strengths of two magnetic fields.	E.g. comparison of the strength of a magnetic field with the horizontal component of the earth's field: experimental investigation of the dependence of the field at the centre of a circular coil on the number of turns and the radius. Questions will not be set on (i) calculation of magnetic field due to a magnet; (ii) oscillations of a magnet in a magnetic field.

Magnetic effects of electric current

SYLLABUS	NOTES
41. Formulae for the strength of the magnetic field due to a current in the following situations: (i) at the centre of a circular coil, (ii) at a distance from a long straight wire, (iii) inside a long solenoid.	Questions on the mathematical derivations of these formulae will not be set.

SYLLABUS	NOTES
42. Force on a current in a magnetic field. Force on moving charge in a magnetic field.	Questions on the mathematical derivation of the formulae involved will not be set.
43. Torque on coil in magnetic field.	Mathematical derivation of the formula for a rectangular coil is sufficient for the examination.
Principle of simple form of current balance.	
Moving coil galvanometer; general features of design; application to use as ammeter, voltmeter, ballistic galvanometer.	In the ballistic galvanometer, only the features of design which render it ballistic need to be studied: mathematical proof of proportionality between charge and throw is not required for the examination.
Electromagnetic induction	
44. Laws of Faraday and Lenz.	Including calculation of induced e.m.f., current, and circulation of charge.
Principle of a method for direct determination of resistance. Application to calibration of voltmeters.	E.g. rotation of a disc within a solenoid.
Eddy currents.	
Self-induction. Mutual induction.	Qualitative treatment only.
45. Simple a.c. and d.c. generators (constant-field type).	
Back e.m.f. in d.c. motor.	
The a.c. transformer.	Factors affecting its efficiency, viz. ohmic loss, eddy current loss, hysteresis loss.
Alternating currents	
46. Instruments for measuring alternating current and p.d.	Moving iron, thermal and rectifier types.
R.M.S. and peak values. Relation between these for sinusoidal a.c.	Proof of relation not required for the examination.
47. Effects of resistance, capacitance and inductance on current and power when each is connected (separately) to an a.c. supply.	Simple qualitative treatment in terms of oscillograms.
Lead and lag.	
Electrostatics	
48. Elementary electrostatic experiments.	Including use of the electroscope as an electrostatic voltmeter.
Distribution of the charge outside and inside conductors at constant potential.	Experimental treatment required.
Principle of van de Graaff machine.	

SYLLABUS	NOTES
49. Law of force between electric charges.	Experimental verification not required.
Idea of an electric field. Electric field intensity, E: force per unit charge and its relation to potential gradient.	
50. Capacitors and the geometrical factors which affect capacitance, C.	For examination purposes, candidates will not be expected to know or to derive the formulae for the capacitance of standard types of capacitor in terms of their dimensions.
The farad, F.	In numerical questions on capacitors the units used will be the farad, volt, coulomb, joule.
Relative permittivity (dielectric constant).	Its effect on capacitance.
Experimental comparison of capacitances.	E.g. by ballistic galvanometer and by calibrated electroscope.
Capacitors in series and in parallel.	
Energy of a charged capacitor.	
	PART 3
Cathode rays and positive rays	
51. Production and properties of cathode rays.	
Measurement of e/m.	By any one method.
Measurement of e by Millikan's method or a similar method.	Stokes' law may be assumed.
Relation between e and the ionic charge.	
The Avogadro constant, L, and its relation to e and the Faraday constant, F.	
Production of positive rays, and determination of charge/mass.	By any one method, e.g. Dempster, Bainbridge. (See also item 58.) Isotopes.
Electronic devices	
52. Diode and triode.	Thermionic emission and the high vacuum diode. Characteristics of diode, including description of space-charge limitation and saturation. The diode as a rectifier; practical methods of rectification of a.c. supply. The triode and its use as a single-stage voltage amplifier.
Cathode ray oscillograph and its use.	Including use of a linear time-base, but not details of its circuit.
53. Transistors.	Structure and simple current—p.d. characteristics. Theoretical treatment (i.e. in terms of holes and electrons) is not required.

SYLLABUS	NOTES
Particle aspect of radiation	
54. Photoelectric effect, and the evidence it provides for the quantum theory. $E = h\nu$.	The principles, but not the details, of the determination of Planck's constant are required.
X-rays	
55. Production and properties.	In hot-cathode tubes.
The diffraction of X-rays.	Bragg's law.
Maximum frequency for a given tube potential.	$h\nu_{(max.)} = eV$.
The atom	
56. Idea of the small nucleus, from α-particle scattering.	
Simple explanation of the occurrence of line spectra.	Qualitative ideas of stable electron energy levels and emission or absorption of light quanta with transition of electrons between levels.
Radioactivity	
57. α- and β-particles and γ-rays: their properties and detection.	By ionization, scintillation and photographic methods. Details of detectors are not required.
Simple absorption and intensity measurements.	
Operation of cloud chamber and G-M tube.	Treated simply.
Safety precautions.	General discussion of radiation damage and knowledge of the circumstances in which types of radiation are particularly harmful.
The nucleus	
58. The proton and neutron.	Explanation of isotopes.
Atomic number and mass number.	
Radioactive decay.	Changes of mass number, A, and atomic number, Z, caused by radioactive decay. Details of radioactive series are not required.
Half-life.	Simple problems on half-life are included, but questions on the decay law $N = N_0e^{-\lambda t}$ will not be set.
Production of artificial radioactive isotopes.	The use of accelerating machines and neutrons should be mentioned but details of methods are not required.
The uses of radioactive isotopes.	One biological and one industrial use.
59. Einstein's mass-energy relation. Energy from fission and from fusion.	The idea of change of mass excess resulting in release of energy. Further details, including chain reactions, etc., are not required.

THE PRACTICAL EXAMINATION. The examiners will not be strictly bound by 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 beam balance will not be set.

The rubric of the Practical Examination papers is as follows:

'*Answer Question 1 and* **one** *other question.*

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

Squared paper and mathematical tables, including reciprocals, are provided.

Write on one side of the paper only.

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 have taken 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.'

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

PHYSICS (ADVANCED LEVEL)
REGULATIONS FOR THE EXAMINATION OF INDIVIDUAL PROJECTS

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 projects in accordance with their own particular interests in Physics, and with the facilities available.

Each school which intends to enter candidates for a project must send to the Syndicate for approval, on forms 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 30 March in the year preceding that in which the candidates will sit the Advanced Level examination. Formal entry must also be made on the printed entry form.

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

Wherever possible, candidates should work individually on their projects, 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 a statement of their individual contributions.

The school will be required to send to the Syndicate or to the examiner, as instructed, the candidates' individual accounts of their work, by 30 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.