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Physics

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UNIVERSITY OF CAMBRIDGE
LOCAL EXAMINATIONS SYNDICATE

SYLLABUSES

SCIENCE SUBJECTS

1966 and 1967

GENERAL CERTIFICATE OF EDUCATION
(ORDINARY LEVEL)

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PHYSICS

(*May not be taken with General Science or Physics-with-Chemistry*)

There will be one $2\frac{1}{2}$-hour theory paper and a test of practical work.

(*a*) The written paper will be divided into two parts. Part I will consist of short-answer questions which may be set on any items of the syllabus. Part II will be subdivided as follows: Section A: General Physics (three questions). Section B: Heat, Light, and Sound (four questions). Section C: Magnetism and Electricity (three questions). Candidates will answer Part I and five questions, including at least one from each section, from Part II. (100 *marks*.)

(*b*) The practical test will require $2\frac{1}{4}$ hours. There will also be an Alternative-to-Practical paper ($1\frac{1}{2}$ hours). (30 *marks*.)

DETAILED SYLLABUS

§21 is an alternative (suitable for 'non-mathematical' candidates) to §§21, 19 and 20. The examiners will set alternative questions on these topics.

1. Measurement of length and of volume.

   Both f.p.s. and c.g.s. systems are expected. Candidates will not be asked to *describe* a vernier or a screw-gauge, but may be expected to use them in the practical examination.

2. Measurement of time by use of the simple pendulum.

A knowledge of the formula relating periodic time to length of the pendulum will not be expected; if required in the practical examination it will be given.

3. Densities of solids and liquids.

The experimental determination of densities, e.g. by density bottle or by weighing and use of a measuring cylinder, is expected.

4. Pressure in liquids and gases; transmission of fluid pressure; the hydraulic press.

Quantitative formulae are required.

5. Boyle's law.

An experimental demonstration for air is included.

6. Mercury and aneroid barometers.

7. Bicycle pump; force pumps and lift pumps; the syphon.

A simple explanation of the syphon in terms of hydrostatic pressures only is required.

8. Principle of Archimedes.

The application of the principle to the determination of densities of solids and liquids is included.

9. Flotation; the common hydrometer.

The treatment should include ships and balloons. Nicholson's hydrometer is NOT required.

10. Simple ideas of force producing movement and acceleration. Inertia.

Examples of bodies moving with constant acceleration, and with constant velocity should be treated.

11. Levers; principle of moments; wheel and axle.

The application to simple problems on parallel forces in equilibrium is expected.

12. Velocity ratio, mechanical advantage and efficiency of machines.

Levers, wheel and axle, single-string pulley systems (e.g. pulley blocks), the inclined plane, the screw and the hydraulic press are included.

13. Centre of gravity treated experimentally; its relation to stability of equilibrium.

Stable, unstable and neutral equilibrium are included.

14. (*a*) *The common balance.*

The structure and use of an accurate form of balance are expected; treatment should include correct weighing with a balance with unequal arms.

(*b*) *Hooke's law: elastic limit.*

The extension of a spring or rubber, treated experimentally. The spring balance is included. Moduli of elasticity are not included.

15. Simple experiments on friction, *including a determination of the coefficients.*

16. Work, energy, power, the transformation and conservation of energy applied to the *quantitative* conversion of energy into its different forms (mechanical, electrical, thermal).

Horse-power is included.

17. Vector quantities; the resolution and composition of inclined velocities and forces.

18. *Problems involving the equilibrium of three non-parallel forces.*

A statement of the theorem of the triangle of forces is NOT *required.*

19. *Velocity and acceleration; the equations of uniformly accelerated motion.*

The treatment should include problems on motion under constant acceleration, e.g. bodies falling freely under gravity, and a qualitative conception of the effect of air resistance (terminal velocity).

20. *Force; inertia; mass.*

Problems on the equation 'force = mass × acceleration' may be set. The distinction between mass and weight is required.

21. Simple phenomena of surface tension; capillarity; *viscosity; diffusion and osmosis.*

A simple explanation in terms of intermolecular forces and of molecular motion should be given (see also kinetic theory). No quantitative treatment is expected.

22. Mercury and alcohol thermometers; Celsius and Fahrenheit scales.

Maximum and minimum thermometers, including the clinical thermometer, and the determination of the fixed points are to be described.

23. Thermal expansion of solids, liquids and gases; effects and applications of expansion.

Effects such as expansion of railway tracks, clock pendulums and balance wheels, and their compensation; applications such as thermostats, riveting.

24. *Determination of the coefficient of linear expansion.*

Experiments on volume coefficients may be set in the practical examination but full details will be given to the candidates.

25. Maximum density of water.

Its application to freezing of ponds, etc., should be discussed.

26. Relation between volume and temperature of a gas.

The variation in volume of dry air enclosed in a capillary tube might be given as an example.

27. Absolute temperature; the gas equation pv/T = constant.

A knowledge of the pressure coefficient at constant volume is not expected. The use of a constant volume gas thermometer based on two fixed points is expected.

28. Quantity of heat; calorie, B.t.u., therm; specific heat; water equivalent; meaning of calorific values of fuels and foodstuffs.

29. Determination of specific heats of solids and liquids.

The method of cooling is NOT required.

30. Change of state; evaporation and boiling; latent heats of fusion and vaporization.

The work should include cooling by evaporation and the determination of latent heats of fusion and vaporization for water.

31. Boiling and melting points and the influence of pressure and of dissolved substances on them. Freezing mixtures.

Cooling curves as applied to the determination of melting points should be included. Calculations on the depression of freezing point and elevation of boiling point are not required.

32. *Saturated and unsaturated vapours; vapour pressure.*

The determination of saturated vapour pressure by barometer tube methods is required.

33. *Relation of saturated vapour pressure to boiling point.*

34. Dewpoint *and its determination by a simple method; the simple atmospheric phenomena related to it.*

Examples should include dew, mist, hoar frost, 'sweating of walls'.

35. *Simple qualitative treatment of kinetic theory.*

The theory should be applied to explain the pressure exerted by a gas, Boyle's law, and the phenomena associated with change of state.

36. Heat as a form of energy.

The determination of the mechanical equivalent of heat by a simple method is required.

37. Conversion of heat into work.

This should be illustrated by steam and internal-combustion engines treated very simply.

38. Transfer of energy by conduction, convection and radiation

The phenomena should be illustrated by simple experiments. Related topics should include: the conductivities of common materials in relation to their uses, e.g. cotton and woollen clothing; the Davy lamp; heat insulation; hot-water systems; motor-car cooling systems; ventilation; land and sea breezes; the vacuum flask.

39. Effect of nature of a surface on the energy radiated and absorbed by it.

40. Rectilinear propagation of light; shadows, eclipses.

The pin-hole camera should be included.

41. Reflection of light; formation of images by plane mirrors; relation of angle of incidence to angle of reflection.

Candidates may be expected to do experiments with converging mirrors, but they will not be expected to know the mirror formula. Questions on curved mirrors will not be set in the theory papers.

42. Refraction at a plane surface; relation of angle of refraction to angle of incidence; refractive index; Snell's law.

Practical work should include the determination of refractive index by tracing rays of light through a parallel-sided glass block.

43. Total internal reflection, including a qualitative treatment of critical angle.

The calculation of critical angle will not be expected. The treatment should cover totally reflecting prisms *as used in prism binoculars.*

44. Converging and diverging lenses; real and virtual images.

Include the magnifying glass, the camera and the projection of large real images by a single converging lens, as in the projection lantern.

45. Focal length of a converging lens; graphical constructions *and formulae* connecting the positions and relative sizes of object and image for the converging lens.

46. The physics of the human eye; accommodation; long sight and short sight and their correction by spectacles.

The simple functions of the cornea, the aqueous and vitreous humours, the iris, the crystalline lens, and the retina should be described. Physiological details of the eye are not required, and calculations on spectacle lenses will not be set.

47. *The compound microscope and the astronomical refracting telescope, including the tracing of rays of light from a distant object to the observer's eye in such a way as to show the nature and positions of the images formed.*

The treatment should include the construction of prism binoculars, without ray diagrams. Single objective and single eye lenses only need be considered

48. Simple experiments on the dispersion of light by a prism.

White and monochrome light should be included.

49. *Elementary treatment of the spectrum including the simple characteristics of near infra-red, visible, and near ultra-violet radiations.*

The treatment should cover simple phenomena such as the penetration of infra-red radiation through fog, and its detection by its heating effects; the detection of ultra-violet radiation through fluorescence and its photographic effect.

50. *Continuous and line emission spectra.*

Examples such as the spectra from a filament lamp and from suitably coloured Bunsen flames.

51. *Simple absorption spectra; the colours of materials.*

Examples such as spectra obtained by the use of coloured filters and solutions.

52. Mixing of coloured lights.

This should be contrasted with the effects of mixing pigments.

53. Production of sound by vibrating systems; its transmission in a material medium.

Descriptions of vibrating sources, e.g. tuning forks, and of experiments to demonstrate the necessity for a material medium are expected.

54. Determination of the velocity of sound by a simple method.

Methods in free air or using a resonance tube are acceptable. The effects of temperature and of wind should be treated qualitatively.

55. Reflection of sound.

Include echoes.

56. Frequency and its relation to pitch.

Examples might include experiments with a siren or a toothed wheel.

57. Frequency of note emitted by a stretched string in relation to length, tension, and mass per unit length of the string; application to any one string instrument.

A qualitative treatment only is required for a string sounding its fundamental note.

58. Frequency of the note emitted by an air column closed at one end in relation to its length.

59. *Quality of a musical note; application of the fundamental principles of sound to instruments of the orchestra.*

Simple treatment of overtones produced by vibrating strings and air columns is required.

60. Resonance.

Mechanical and acoustical examples should be included.

61. Simple phenomena of magnetism.

Include the properties of magnets, magnetic induction, magnetic screening (or shielding), distinction between magnets and unmagnetized magnetic materials, methods of magnetization and demagnetization, magnetic fields and lines of force with a qualitative treatment of neutral points. Questions involving a knowledge of molecular theories of magnetism will not be set.

62. Magnetic properties of iron and steel.

Simple experiments illustrating the differences between these materials when used as electro- and as permanent magnets should be given. A knowledge of hysteresis is not required.

63. The magnetic field of the earth.

A qualitative treatment of declination (variation) and dip is expected.

64. One good form of compass.

65. Simple voltaic cell; Leclanché cell (wet and dry).

Include polarization, local action, and back e.m.f. due to polarization.

66. Accumulators.

EITHER the lead OR the iron type is acceptable, but only simple theory, without chemical equations, is required. Care and maintenance, including practical details of charging and discharging, should be described.

67. The ampere; the coulomb; potential difference; electro-motive force; the volt; the watt, kilowatt and kilowatt-hour.

The relationships between the coulomb, the joule and the volt, and between the volt, the ampere and the watt are expected. Calculations of electrical energy involving cost may be set.

68. The magnetic effect of an electric current.

The magnetic field associated with a current-carrying conductor, e.g. straight wire, circular coil, solenoid. Electro-magnets and the electric bell.

69. Behaviour of a coil carrying a current in a magnetic field; the D.C. motor; galvanometers and ammeters.

Moving coil and moving iron (repulsion type) instruments should be described. The use of wire suspensions, and of lamps and scales, is not expected. (*In the Practical Examination, the use of tangent galvanometer as an alternative to ammeter will be permitted; but no questions involving the theory of the tangent galvanometer will be set in the theoretical papers.*)

70. Ohm's law; resistance; the ohm, *resistivity;* internal resistance of cells.

Calculations involving series and parallel arrangements of resistors and of cells may be set. Ohm's law should be applied to single resistors and to whole circuits.

71. Ammeter shunts; voltmeters.

72. Comparison of resistors by the metre bridge, *and of e.m.f's by the potentiometer.*

The measurement of internal resistance of a cell is not required.

73. The heating effect of an electric current.

Applications, such as electric fires, irons, and filament lamps should be included. *Numerical examples may be set.*

74. The wiring of buildings; the use of switches and fuses.

Safety precautions, e.g. earthing, should be explained.

75. The chemical effect of an electric current; electrolytes and non-electrolytes; *Faraday's laws; electro-chemical equivalent and the measurement of current electrolytically.*

Elementary phenomena of electrolysis, including the electrolysis of acidulated water, and of copper sulphate solution using copper electrodes or platinum electrodes. Electro-plating should be described.

76. Experiments to illustrate the phenomena of electro-magnetic induction; laws of electro-magnetic induction.

The treatment should include the simple induction coil.

77. Alternating current; a simple A.C. generator; the transformer; the grid system of transmission of electrical energy.

A coil rotating in a magnetic field is sufficient. Advantages of A.C. and of high voltage transmission should be included.

78. *The simple* D.C. *generator.*

A simple A.C. *generator modified by the use of a commutator is expected. The treatment should include a comparison of the* D.C. *produced with that obtained from batteries.*

79. Telephone transmitter and receiver, and their connections in a simple circuit.

A carbon microphone and a moving diaphragm receiver are expected.

PRACTICAL PHYSICS

(*Not for candidates offering Physics-with-Chemistry*)

This will be tested by a PRACTICAL EXAMINATION based on the above syllabus, except that there will be no questions on sound. The object of the practical examination is to test whether the candidates have worked through a satisfactory course in the laboratory and are capable of handling simple apparatus. The questions will, as far as possible, contain detailed instructions for all the operations to be performed. Even when standard experiments such as the determination of focal lengths or specific heats are asked, candidates will be told what readings to take and how to calculate the result. It should not therefore be necessary for candidates to learn by heart how to do any experiments.

In addition to experiments on topics in the syllabus, candidates may be asked to carry out with aid of full instructions:

1. Variants on standard experiments, e.g. specific heats of two metals compared and not actually measured.

2. Experiments involving measurements where knowledge of the theory is not expected, e.g.: bending of a metre ruler weighted at the centre; heat evolved when two liquids are mixed; relative coefficients of expansion of liquids by S.G. bottle; location of *real* images applied to various simple determinations with spherical mirrors and

lenses (either pin and parallax or light box and screen methods are acceptable).

Questions may also be set involving measurements with a vernier and screw-gauge, the plotting of rays through prisms with pins, the plotting of magnetic fields by compass needle and the location of neutral points.

The candidates should be trained to take as varied a set of readings as possible and to set out the actual observed readings systematically on one of the sheets of paper sent up. The experiments may require exhibition of results graphically and deduction from the graphs, e.g. interpolation, intercepts, slope of a straight-line graph. During the first 15 minutes of the Practical Examination candidates will be allowed to see the apparatus, but not to start work. This time is intended to enable them to read through the paper and choose their questions.

Questions on calorimetry will as far as possible contain alternatives for candidates trained to use thick calorimeter methods.

ALTERNATIVE-TO-PRACTICAL PHYSICS. The Practical Physics paper will be alternative to a 1½-hour written paper to be known as the Alternative-to-Practical paper. This paper is designed to test a knowledge of the practical work cognate to the theoretical syllabus: candidates taking it are required to submit satisfactory evidence that they have undergone a proper course of laboratory work. (See p. 5.)