

Engineering Science 150

This subject may be taken at the June examination only.

ORDINARY LEVEL ONLY

Aims

Engineering is the art of the utilisation of natural resources, human experience and scientific knowledge in the modification of the environment to meet the needs of man.

Engineering Science comprises those branches of the physical sciences needed for the practice of the art of engineering.

The Engineer is involved in the collection, analysis and evaluation of data, the application of known scientific principles and the design of appropriate devices and methods for the solution of given physical problems. Any course in Engineering Science should draw illustrations from this kind of activity and should provide an opportunity for students to begin to develop these skills.

Objectives

Two kinds of achievement will be tested in the examination: a knowledge and understanding of the subject matter in general terms and the ability to apply this knowledge and understanding to particular systems and problems. In addition it is hoped that the student will develop an awareness of current trends in engineering and examples of present day developments and their effects.

The Examination

The examination will consist of two papers: one of 1 hour (40%) and one of 2 hours (60%). *Paper 1 (1 hour)* will contain ten short questions covering topics from the whole syllabus, with no choice. *Paper 2 (2 hours)* will contain eight longer questions from which candidates will be required to choose four. The questions may be set on topics from any part of the syllabus and will be designed to include the testing of the ability to apply knowledge and understanding to particular systems and problems. An essay-type question may be set on section 7 of the syllabus. A quantitative treatment will not be required for this question, but candidates should show an awareness of the strength of evidence upon which the views they express are based, and include numerical data where appropriate.

Questions will be set in SI units (see **General Information**).

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

$+$, $-$, $\times$, $\div$, π, x^2, $\sqrt{x}$, $\frac{1}{x}$, x^y; sine, cosine and tangent and their inverses in degrees and decimals of a degree.

Syllabus

This syllabus is intended to indicate the scope of the examination: it does not dictate the teachers' approach to the subject. Each section of the syllabus includes explanatory notes which give guidance on the treatment intended. Neither the arrangement in sections nor the length of these sections implies anything about the relative weights of the topics examined.

Emphasis is laid on the fact that engineering science is an experimental science and any course on this syllabus should be firmly based on laboratory work, carried out as

far as possible by the students. Illustrations should be drawn from current engineering practice, wherever possible. An understanding of the principles rather than factual recall is central to the syllabus, and formal statements of laws (such as Newton's laws) will not be required, but candidates will be expected to use scientific terms in the correct context.

SYLLABUS	*NOTES*
1. *Energy*	
The concept of energy. The joule. Forms of energy. The principle of conservation of energy. Energy, work and power. Efficiency. Energy loss from systems.	An introduction to all forms of energy with qualitative examples of how these can be transformed into another. Numerical questions may be set to test knowledge and understanding of energy, work and power relationships.
Mechanical energy. Potential energy due to gravity. Kinetic energy. Work done in linear motion, the force-distance graph. The transmission of mechanical energy and power.	A descriptive treatment *only* of forms of transmission of mechanical power.
Internal energy. Simple kinetic theory. Temperature and absolute zero. The transmission of thermal energy: conduction, convection, radiation.	Temperature as a measure of the average molecular kinetic energy of a substance. A descriptive treatment *only* of transmission of thermal energy.
Electrical energy and power. The generation and transmission of electrical energy.	Comparison of the merits of different types of generating station. The advantages of high voltage transmission, the grid system.
The nature of a system. Open and closed loop systems. Feedback, negative and positive.	A descriptive treatment *only* of simple mechanical, thermal, fluid, electrical and control systems, based upon the block or schematic form of diagram. Examples such as the spring-mass, d.c. motor, speed governor and radio amplifier.
2. *Materials*	
The structure of matter.	The elementary concept of the nuclear atom. A simple descriptive treatment of the microstructure of engineering materials.
Conductors, semiconductors and insulators.	A descriptive treatment, using the atomic model of simple electronic and ionic conduction in solids.
Metals: properties and uses.	Iron, copper, aluminium. The effect of alloying on properties. Steels, brasses, bronzes, aluminium alloys. Presence of free graphite in cast iron.
Concrete: properties and uses.	Compressive strength and weakness under tension, reinforced concrete, fire resistance.
Plastics: properties and uses.	The terms thermoplastic and thermosetting. Resistance to corrosion, low relative density, pleasing appearance, rapid fall in strength with rise in temperature, fire risk.
Choice of materials for engineering purposes.	Properties which influence design and manufacture, e.g. tensile strength, elasticity, hardness, toughness, corrosion resistance, cost, fluidity, ductility, plasticity, malleability.

SYLLABUS	*NOTES*
Tensile stress and strain, Hooke's elastic law and the Young modulus of elasticity. Tensile testing of materials.	Simple numerical questions may be set on this topic. The features of the nominal stress-strain curve of mild steel and other materials as examples. A brief discussion of the design stresses arising from the variety of working environments and loadings.
3. *Waves and Fields*	
An introduction to the production and propagation of waves.	A practical treatment, e.g. using the ripple tank. Examples of naturally occurring wave motion and their mode of travel, including electromagnetic waves.
Amplitude, period, frequency, phase, velocity and wavelength of simple waveforms.	Numerical questions may be set on the relationships $v = f\lambda$ and $f = \frac{1}{T}$. The sine wave as an example.
Oscillatory motion: the pendulum, mass-spring system. Simple harmonic motion. Free and forced vibrations. Resonance, damping.	Sinusoidal representation of s.h.m. A descriptive treatment, but questions may be set which involve the use of given formulae such as $T = 2\pi\sqrt{\frac{l}{g}}$ for a pendulum.
Alternating current. The sine wave: peak, average and r.m.s. values, frequency.	
The phenomena of magnetism. Magnetic properties of iron and steel. The magnetic effect of a current. Magnetic field due to a current in a conductor. The solenoid.	A descriptive treatment *only* of magnetism and electromagnetism.
The concept of the magnetic field. Flux and flux density. The electromagnet and its application in the relay and the electric bell.	Numerical questions will *not* be set on flux density in magnetic circuits.
The electric field and field strength. Capacitance. The parallel plate capacitor. Capacitors in parallel.	The factors that influence capacitance and the use but *not* the derivation of the equation $C = \frac{\epsilon A}{d}$. Numerical problems will *not* be set on field strength in electric fields. The use of capacitors as energy stores and for smoothing purposes.
4. *Mechanics*	
Scalar and vector quantities.	The addition, subtraction and resolution of vectors. Questions will be restricted to force and relative velocity problems.
Rectilinear motion: speed and linear acceleration; distance-time and speed-time graphs; equations of motion.	Free fall as a special case, acceleration of free fall. Equations, without derivation, for uniform acceleration only.
Force, mass, linear momentum. Newton's laws of motion. Relation between mass and weight.	An understanding rather than a formal statement of Newton's laws. g as the specific force of gravity.

SYLLABUS	NOTES
Rotational motion: angular displacement and angular speed.	By analogy with linear motion.
Resolution of forces: equilibrant and resultant forces.	Questions will be restricted in this and subsequent topics to coplanar systems.
Conditions of equilibrium. Systems of coplanar forces in equilibrium. Polygon of forces. Moments and law of moments.	Bow's notation may be useful in this connection, but its use is *not* specifically required. Application of the law of moments to simple levers.
The centre of mass of a body and the centroid of an area and their determination.	Questions will be restricted to combinations of simple shapes with known centres of mass.
Friction: coefficient of friction.	Distinction between limiting static and dynamic friction. Useful aspects of friction, for example in locomotion and braking, and in clamping. The need to reduce friction when power is transmitted.
Simple machines. Mechanical advantage, velocity ratio, efficiency.	Questions restricted to single string pulley systems, the screw jack, the winch, simple gear trains.
Fluids at rest. Fluid pressure. Atmospheric pressure. The manometer and barometer. Archimedes' principle.	Formula for variation of liquid pressure with depth. A descriptive treatment *only* of atmospheric pressure. Distinction between gauge pressure and absolute pressure.
Simple pumps and turbines. The siphon.	A descriptive treatment *only* of pumps, turbines and siphon.
5. *Electricity*	
Current, charge and potential difference. Ohm's law. Resistance. Kirchhoff's laws. Resistors in series and parallel. Power in a d.c. circuit.	The coulomb as the ampere second. The volt as the joule/coulomb. Questions will *not* be set on circuits with more than two loops.
Resistivity of solids. The temperature coefficient of resistance.	The use, but *not* the derivation, of the equations $R_\theta = R_\theta\ (1 + \alpha\theta)$ and $R = \rho\frac{l}{A}$ as applied to solid materials only.
Force on a current-carrying conductor in a magnetic field and its application. Fleming's left-hand rule. The principles of the d.c. motor, the moving coil loudspeaker.	The use but *not* the derivation of the equation $F = BIl$. A descriptive treatment *only* of the d.c. motor and loudspeaker.
The e.m.f. induced in a conductor moving through a magnetic field. The laws of Faraday and Lenz. Fleming's right-hand rule. The simple d.c. generator, the microphone.	The use but *not* the derivation of the equation $E = Blv$. Simple linear problems may be set on the Faraday/Lenz laws requiring an understanding of the factors involved in the generation of an e.m.f. A descriptive treatment *only* of the d.c. generator and microphone.
Primary and secondary cells. The lead and alkali accumulators. The use and care of accumulators.	A descriptive treatment *only* of the construction and action of cells. Knowledge of the chemical equations will *not* be requi[illegible]

SYLLABUS	NOTES
Electricity in the home. Simple house wiring, fuses, switches and protective arrangements. Safety in the use of electricity. The heating effect of an electric current and its applications. The electric kettle, fire and water heater.	A descriptive treatment *only* is required but numerical questions may be set using examples from this section to test knowledge and understanding of basic principles. It is suggested that candidates are made aware of the means of resuscitation after electric shock, but this topic will *not* be examined.
Alternating current. Basic principles of the a.c. generator and transformer.	Numerical questions may be set on the power balance and the equation $\frac{V_1}{V_2} = \frac{N_1}{N_2}$ as applied to the transformer, but otherwise descriptive treatment *only* of the transformer and generator.
Basic principles of the semiconductor diode and transistor. The diode as a half-wave rectifier. The simple transistor resistance loaded amplifier; the load line.	A simple descriptive treatment *only* of the physical principles of semiconductor devices. The common emitter amplifier arrangement *only*. Load line problems may be set using the output characteristics and load line equation.
Movement of electrons under the influence of electric and magnetic fields. Thermionic emission. The cathode ray tube.	A descriptive treatment *only* of the electrostatic and electromagnetic deflection of electrons, as employed, for example, in the CRO and television tubes.
Simple electrical measurements. The basic principles of ammeters and voltmeters, moving coil and moving iron types. The multi-range meter. Simple electro-mechanical and electro-thermal transducers.	Simple numerical problems may be set on the Wheatstone bridge circuit (for resistance measurement) and the potentiometer circuit (for voltage measurement). Principles of operation of meters, without constructional details. A simple descriptive treatment of common transducers such as the thermocouple, gramophone cartridge and resistive strain gauge.
6. *Thermodynamics*	
Temperature and its measurement. Absolute zero.	The principles of operation of mercury-in-glass, thermocouple, and resistance thermometers.
Heat capacity. Specific heat capacity. Specific latent heat of fusion and vaporisation.	Details of experimental determination are *not* required.
Calorific values of fuels.	Simple calculations may be set.
Thermal expansion of solids, liquids and gases. Linear expansivity of a solid.	Simple consequences and applications. The use, but *not* the derivation, of the equation $l_\theta = l_0\ (1 + \alpha\theta)$.
Boyle's law, Charles's law. The characteristic equation of a perfect gas.	Specific gas constant. The use of the equation $pV = nRT$.
Petrol and diesel engines; four-stroke cycle; energy losses.	Factors affecting performance, e.g. compression ratio, load.
Refrigerators and heat pumps. Cooling by expansion or evaporation.	A descriptive treatment in the form of a block diagram of the parts of the system. A descriptive treatment of energy flow.

SYLLABUS	*NOTES*
7. Social and Environmental Effects	
A brief introduction to the effects of technological change.	A question may be set with a choice of topics within this field. Awareness of factors such as: accelerating pace of change, widening material choice, changing affluence, rate of consumption of resources, control of working/living conditions, pollution and noise, development of alternative technology to meet future needs. The interrelationship of such factors.

A booklist is available on request to the Secretary (see **General Information**).

English

The syllabuses available are:

ORDINARY LEVEL

English Language, Syllabus A *Subject number* **160**

English Language, Syllabus B *Subject number* **161**

Candidates may take only one syllabus in English Language at Ordinary level, either Syllabus A or Syllabus B.

English Literature *Subject number* **171**

English Literature at Ordinary level may not be taken in combination with either English Literature or English (either Syllabus A or Syllabus B) at Advanced level.

ADVANCED LEVEL

English Literature *Subject number* **170**

English Language Studies *Subject number* **174**

Available to Schools only.

English Syllabus A *Subject number* **175**

English Syllabus B *Subject number* **176**

English Literature at Advanced level may not be taken in combination with English (either Syllabus A or Syllabus B) at Advanced level or with English Literature at Ordinary level.

English Language Studies at Advanced level may not be taken in combination with English (either Syllabus A or Syllabus B) at Advanced level.

English (either Syllabus A or Syllabus B) at Advanced level may not be taken in combination with English Literature at Ordinary level.

A Special paper will be set in these subjects: see Regulation 8.3.

*Text or Authors marked * in these syllabuses are new prescriptions for June 1989 and January 1990 and will also be prescribed for June 1990 and January 1991; other texts may also be prescribed for a further year.*

Where no particular editions of the Chaucer and Shakespeare set texts are prescribed for the English Literature papers the examiners will use the following editions for any passages set in questions:

Shakespeare: ed. Alexander (Collins) Chaucer: ed. Robinson (2nd ed. Oxford).

ORDINARY LEVEL

English Language Syllabus A 160

Aims

This syllabus is intended for candidates for whom English is a primary language. **English Language, Syllabus B** (*Subject number* **161**) is an alternative syllabus for speakers of other langu[illegible].