SYSTEMS AND CONTROL

It is recommended that the approach to the following objectives should be a practical one wherever possible and that their delivery to students be used as the vehicle for delivering the content of Part 1 such that the syllabus is seen as an integrated area of study.

Introduction

This area of study is concerned with developing the skills and knowledge used by designers within the context of a group of related technological resource areas; namely Structures, Mechanisms and Electronics. It is intended that practical experience be used to create a broad understanding of the three resource areas and by identifying how they interrelate, their role in designing and making controlled systems can be appreciated and exploited.

	Candidates should be able to:
Designing and Making	design and make working models and practical products using the concepts, knowledge and skills listed, and resistant materials, components and kits;
	design, make and evaluate a static structure;
	use the principle of levers to design and make a simple machine that is structurally sound;
	use electric motors and solenoids to power simple mechanical models, and both bread-boarded and pcb built electronic circuits to control them;
Testing	use a simple dial gauge to measure the deflection of simple structures;
	be aware of the use of strain gauges for testing, common structural and mechanical members/ components under strain;
Moments (Turning Forces)	define a moment as force x distance (Nm); demonstrate an understanding of the use of moments in simple calculations relating to the loading of beams and levers;
Energy	describe the power sources used to drive mechanical systems and recognise a battery as an electrical energy storage/conversion device;
	be aware of the energy costs of powering systems and how, through good design and manufacture, the potential energy demand can be reduced;
Structure and Forces	calculate and analyse simple forces using triangle and parallelogram representation; examples will include support wires, tripods, shear legs and frames;
	understand the design and construction of structures which withstand stress and take stationary and moving loads;
Types of Structure	identify and classify both natural and man-made structures as they occur in everyday life;
Types of Structural Member	draw, describe and identify various types of member such as beam, strut and tie;

Materials	describe, compare and contrast the properties of the following structural materials when used in the construction of beams, frames, arches and cables: – woods, metals, stone, concrete, plastics and composites;
Nature of Structural Members	be aware of how performance is affected by length, shape of cross-section and material selection;
Joints in Structures	apply sound judgement when selecting the appropriate method of joining materials of solid and hollow cross section; select and use different methods of reinforcing such as gussets, ribs, braces and laminating;
Framed Structures	recognise frames in use and identify the use of triangulation to establish rigidity;
Applied Loads and Reactions	apply the concept of equilibrium as a result of applied load and reaction; understand what is meant by the following terms and their relationship to structural design: tension, compression, shear, bending, torsion and static load (simple examples only);
Forces	understand Hooke's Law and the relationship between extension and load; understand Stress = $\frac{\text{force}}{\text{cross sectional area}}$ understand Strain = $\frac{\text{change in length}}{\text{original length}}$ understand Young's Modulus of Elasticity as: $\frac{\text{Stress}}{\text{Strain}}$ (N/mm^2) draw and interpret a typical stress/strain graph for mild steel and identify the important features on this graph; understand the significance of these features to structural design; understand the term Factor of Safety and its importance to structural design.
Mechanisms	
General Concepts	explain and use the following terms correctly: – load, effort, fulcrum, mechanical advantage, velocity ratio and efficiency;
Levers	identify and sketch simple examples of first, second and third order levers, and associated linkages;
Transmission of Motion	select appropriately and list the factors influencing the choice of the following for practical applications: Gears – spur, bevel, worm, rack and pinion; Belts and Pulleys – flat, toothed, round and vee belts and pulleys; – sprockets and chains; – standard systems to maintain tension in drive belts and chains; calculate simple gear ratios and transmission speed;

	determine the Mechanical Advantage (MA), Velocity Ratio (VR) efficiency and rotational direction for the following: – wheel and axle, screw jack, compound pulley and gear arrangements;
Bearings and Lubrication	be aware of the need to reduce friction between two surfaces by design, and describe the types of lubrication, and other methods of application for different situations; compare and contrast the use of plain, roller and ball bearings, and give reasons for their suitability for specific operational conditions;
Conversion of Motion	recognise and give examples of the following types of motion: – rotary, linear, reciprocating and oscillating; understand the terms crank, cam, follower, dwell, stroke, screw thread, pitch; compare and select appropriately crankshafts, crank/slider mechanisms, rack and pinion, ratchet and pawl, eccentrics, simple cams and screw threads as methods of converting motion from one type to another.
Electronics	
Basic Concepts	use correct symbols and conventions when drawing circuit diagrams; describe the operation of a circuit in terms of conventional current flow; identify and compare the following properties when selecting materials: – conductivity and insulation; understand and apply units used to measure current, voltage, resistance and capacitance, including multiple and sub-multiple units; understand the relationship between current, voltage and resistance (Ohm's Law) and use to calculate the value of a current limiting resistor; use ammeters, voltmeters and multimeters to measure current, voltage and resistance; perform simple power calculations using $P = VI$;
Switches	understand the action and application of common switches: – toggle, push button (PTM/PTB), micro, rotary and reed; understand the terms normally closed (NC), normally open (NO), single pole single throw (SPST) and double pole double throw (DPDT) in relation to switches and relays; use relays to switch higher voltage circuits for motors, solenoids etc.; construct and draw circuits which use a two pole change-over relay to give motor reverse control and latched (memorised) switching;

Resistors	make use of the resistor colour code to determine the value and tolerance of a resistor and to select the nearest suitable value; draw circuit diagrams and perform calculations for resistors in series and parallel; understand the term potential divider and perform calculations to determine values of resistance and voltage in potential divider circuits;
Transistors	Describe the operation of transistors in terms of the collector emitter circuit being controlled by the base bias voltage. Select appropriately the use of NPN transistors as switches in circuits;
Diodes	understand the use of a diode as a one way conductor, and its use in a relay circuit to protect against back emf; use LEDs in circuits and be able to calculate the value of a suitable current limiting resistor to protect LEDs;
Transducers	understand the use of the following transducers: – LDR, thermistor, strain gauge;
Capacitors	explain with the aid of diagrams/graphs, the charging and discharging of a capacitor;
Time Delay Circuits	construct and draw circuit diagrams for time delay circuits (monostable and astable) using capacitors, resistors, transistors and the 555 timer IC; use T = C x R to calculate simple time delays; use graphs and data to be able to select components to achieve a desired time delay;
Logic gates	Have knowledge and understanding of the use of logic gates (AND, OR, NAND, NOR, NOT) and truth tables for simple logic control systems. Give examples of the use of logic control systems in everyday life, e.g. heating control, traffic lights, environmental control in a greenhouse etc.