Materials for Technology Students

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Preface

In recent years there have been a number of significant changes in the approach to education for engineering. One of the most important of these changes has been the recognition that the science of materials must form an integral part of any engineering course. In the past, the intensive study of materials normally commenced in Higher National or degree courses. I am very pleased to see that the subject is now introduced in its rightful place as one of the basic foundation studies in the O.N.D. in Technology course and also at G.C.E. Advanced level in engineering science courses. Unfortunately, the O.N.D. in Technology course is only to be a transient phenomenon and will shortly be superseded by the new Technician Diploma and Certificate courses. However, materials science studies will feature prominently in the new courses and technician students should find the style and content of this book suitable for them.

In this book I have used a largely descriptive approach to the very broad subject of materials which should be suitable for students with a background of G.C.E. Ordinary-level science. Some knowledge of differential and integral calculus is needed for the work on elementary stress analysis, but by the time this stage of the materials course is reached the student should be conversant with these techniques from his complementary studies in mathematics.

A number of test questions have been placed at the ends of chapters 5, 6 and 7, the stress analysis section. I have not included revision questions for other chapters because, in very many instances, colleges choose to examine at O.N.D. level by means of multiple-choice objective tests.

I wish to record my gratitude for the help and advice received from colleagues and family during the preparation of this book, in particular Clive Beesley and Ed Drabble of P.C.L. for reading the manuscript and suggesting improvements. I am greatly indebted to my wife for reducing my untidy handwriting to a clean typescript, to my elder son Roger for invaluable assistance in proof reading, and to my younger son Derek for not interrupting too often while the work was in progress.

Vernon John

List of Symbols

<i>Quantity</i>	<i>Symbol</i>
Atomic number	Z
Atomic mass number (atomic weight)	M
Avogadro's number	$N_A = 6.023 \times 10^{23}$ (molecules per mole)
Planck's constant	$h = 6.625 \times 10^{-34}$ Js
Temperature	T or θ
Thermal conductivity	k
Universal gas constant	$R_0 = 8.314$ kJ/kmol K
Frequency	ν (Greek nu)
Direct stress	σ (Greek sigma)
Direct strain	ϵ (Greek epsilon)
Shear stress	τ (Greek tau)
Shear strain	γ (Greek gamma)
Young's modulus of elasticity	E
Modulus of rigidity	G
Bulk modulus of elasticity	K
Poisson's ratio	ν
Force	F
Bending moment (moment of force)	M
Second moment of area	I
Polar second moment of area	J
Torque	T
Power	P
Elastic strain energy	U
Time	t
Glass transition temperature	T_g
Surface tension	γ
Velocity of light	$c = 3 \times 10^8$ m/s

Units

The units used through this book conform to the SI system. The principal units that are quoted in the text are given below. (Since we are in the change-over period, the Imperial equivalents of some SI units are listed.) Preferred SI units are printed in bold type.

<i>Quantity</i>	<i>Unit</i>	<i>Symbol</i>
Mass	kilogram	kg (1 kg = 2.205 lb)
	gram	g
	tonne	t (Mg) (1 t = 1000 kg = 0.984 ton)
Length	metre	m (1 m = 39.37 in.)
	millimetre	mm
Time	second	s
	minute	min
	hour	h
	metre per second	m/s
Velocity	degree Kelvin	K
Temperature	degree Celsius	°C
Amount of substance	mole	mol
	kilomole	kmol
Plane angle	radian	rad (1 rad = $180^\circ/\pi$)
	degree	°
Area	square metre	m²
	square millimetre	mm ²
Volume	cubic metre	m³ (1 m ³ = 35.315 ft ³)
	cubic millimetre	mm ³
Density	kilogram per cubic metre	kg/m³ (1 kg/m ³ = 1000 g/cm ³ = 0.062 lb/ft ³)
Force	newton	N (1 N = 0.225 lbf)
	kilonewton	kN
	meganeutron	MN

<i>Quantity</i>	<i>Unit</i>	<i>Symbol</i>
Moment of force (Torque)	newton metre	Nm (1 Nm = 0.738 lbf ft)
	kilonewton metre	kNm
Stress (pressure)	newton per square metre	N/m² (1 N/m ² = 0.000145 lbf/in ²)
	meganewton per square metre	MN/m ² (1 MN/m ² = 0.102 kgf/mm ² = 0.0648 tonf/in ²)
	giganewton per square metre	GN/m ²
	bar	bar or b (1 bar = 10 ⁵ N/m ²)
Surface tension	newton per metre	N/m
Energy	joule	J (Nm)
	electron volt	eV (1 eV = 1.602 × 10 ⁻¹⁹ J)
Calorific value (mass)	megajoule per kilogram	MJ/kg (1 MJ/kg = 429.5 Btu/lb)
Calorific value (volume)	megajoule per cubic metre	MJ/m ³ (1 MJ/m ³ = 26.81 Btu/ft ³)
Thermal conductivity	watt per metre per degree Kelvin	W/m K
Power	watt	W (J/s)
	kilowatt	kW (1 kW = 1.342 hp)
Second moment of area	metre to the fourth	m ⁴
	millimetre to the fourth	mm ⁴
Electric current	ampere	A
Voltage	volt	V
Quantity of electricity	coulomb	C (As)
Electrical resistance	ohm	Ω (V/A)
Electrical resistivity	ohm metre	Ωm
Magnetic flux	weber	Wb (Vs)
Magnetic flux density	tesla	T (Wb/m ²) (1 T = 10 ⁴ gauss)
Frequency	hertz	Hz (s ⁻¹)