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Thermodynamics

G. Boxer

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Preface

This is not a textbook in thermodynamics; it is a revision tutorial volume. It is assumed that the student has completed a course of lectures in the first year and is reasonably familiar with all the terms in use here. The student should then be able to use this volume for revision purposes in preparing for an examination on the first year's work.

Consequently, no derivation of fundamental equations (e.g. the steady flow energy equation) will be found within these pages. The student is referred to recommended texts given at the end of this volume for this fundamental work or to notes taken during lectures. One exception is in momentum; a reasonably full treatment is given in Chapter 6, making use of the concept of free body diagrams, to help the student to a clearer understanding of a topic that is generally difficult to assimilate.

I have done all I can to make the technical language clear because the correct use of physical symbols (and the dimensions associated with them) is essential to a proper understanding of the subject. I stress within these pages the invaluable help that may be obtained in any fundamental reasoning with the use of unity brackets, which I cannot commend too highly.

I have included a standard procedure for the solution of all problems in thermodynamics wherein the student is encouraged to answer certain leading questions, the correct answers to which will reveal the uniformity of approach possible in this subject. This assumes that the main work of lecturing is over and that the student is now faced with the re-examination, assimilation and application of this work in a logical way. I really believe the standard procedure will be of assistance here.

1987

G. B.

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Nomenclature

A	area
A_s	surface area
a	dimension
B	dimension
b	dimension
C	heat capacity
c	specific heat capacity <i>or</i> dimension
c_p, c_v	the principal specific heat capacities (isobaric, isochoric)
c.s.	control surface
D	diameter
d	prefix for differential quantity (e.g. dx)
E	internal energy (preferred alternative to U in British Standard)
e	specific internal energy ($e = E/m$)
F	force
f	symbol denoting liquid line (from German <i>Flussigkeit</i>)
g	gravitational acceleration
g	symbol denoting saturated vapour line
H	enthalpy
h	specific enthalpy ($h = H/m$) <i>or</i> local coefficient of heat transfer
i	constituent suffix in gas mixtures
K	kelvin unit of temperature on the absolute scale
k	thermal conductivity
L	length
l	length
m	mass
m_v	relative molar mass
$\dot{m}$	mass flow rate ($\dot{m} = dm/dt$)
N	speed of rotation
n	polytropic index <i>or</i> number of kmols of a substance
P	brake load on an engine
p	pressure
Q	heat transfer
$\dot{Q}$	rate of heat transfer ($\dot{Q} = dQ/dt$)
$\dot{Q}'$	rate of heat transfer per unit length
$\dot{Q}''$	rate of heat transfer per unit area
$\dot{Q}'''$	rate of heat transfer per unit volume
q	specific heat transfer ($q = Q/m$)
R	spring rate <i>or</i> specific gas constant <i>or</i> thermal resistance
R_0	universal gas constant
r	radius
r_w	work ratio

S	entropy
s	specific entropy ($s = S/m$)
t	time
t_0	time constant in heat transfer in unsteady state
T	temperature
U	overall coefficient of heat transfer
u	velocity
V	volume
$\dot{V}$	volume flow rate ($\dot{V} = dV/dt$)
v	specific volume ($v = V/m$)
W	work transfer
$\dot{W}$	rate of work transfer or power ($\dot{W} = dW/dt$)
w	specific work transfer ($w = W/m$)
x	principal coordinate <i>or</i> quality (dryness) of vapour <i>or</i> dimension
y	dimension
z	datum height <i>or</i> dimension
α	angle
β	coefficient of cubical expansion
γ	ratio of c_p/c_v
δ	prefix for incremental change (e.g. δx)
η	efficiency
θ	angle <i>or</i> temperature difference
μ	absolute or dynamic viscosity
π	as in area of circle = πr^2
ρ	density or resistivity
σ	Stefan-Boltzmann constant
Σ	sum of
Σ	sum of round a cycle
ϕ	angle
ω	angular velocity

Dimensionless groups

Nu	Nusselt number ($= hL/k$)
Pr	Prandtl number ($= c_p \mu/k$)
Re	Reynolds number ($= \rho u L/\mu$)
Gr	Grashof number ($= L\beta g \theta u^2/\mu^2$)
Pe	Peclet number ($= uL/\alpha$ where $\alpha = k/\rho c$)
Ec	Eckert number ($= u^2/c\theta$)

Other symbols

$\equiv$	equivalent to
$\propto$	proportional to
$>$	greater than
$<$	less than
$\geq$	greater than or equal to
$\leq$	less than or equal to
$\uparrow$	increasing
$\downarrow$	decreasing
∞	infinity
$\approx$	approximately equal to
$\cdot$	maximum (e.g. $\hat{p}$ = maximum pressure)
ϕ	a function of