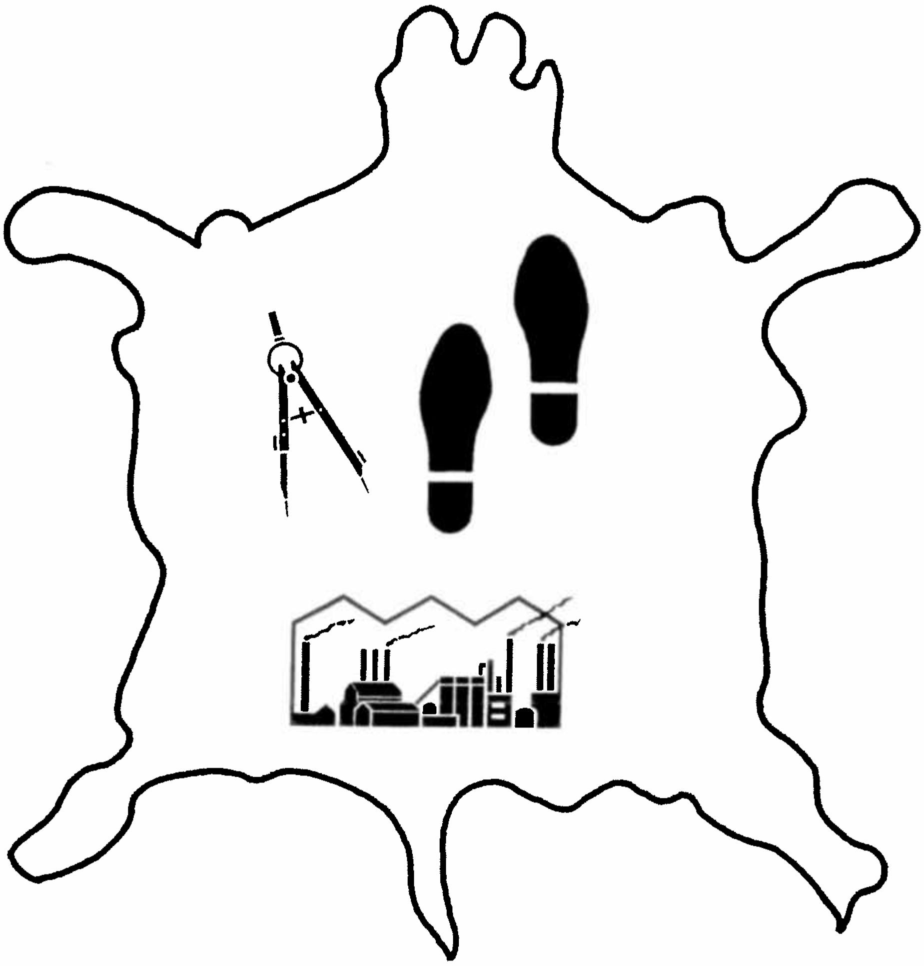
SHOE INDUSTRY
CERTIFICATE COURSE

UNIDO

SI METRIC SYSTEM OF MEASUREMENT*



* This document has been produced without formal editing

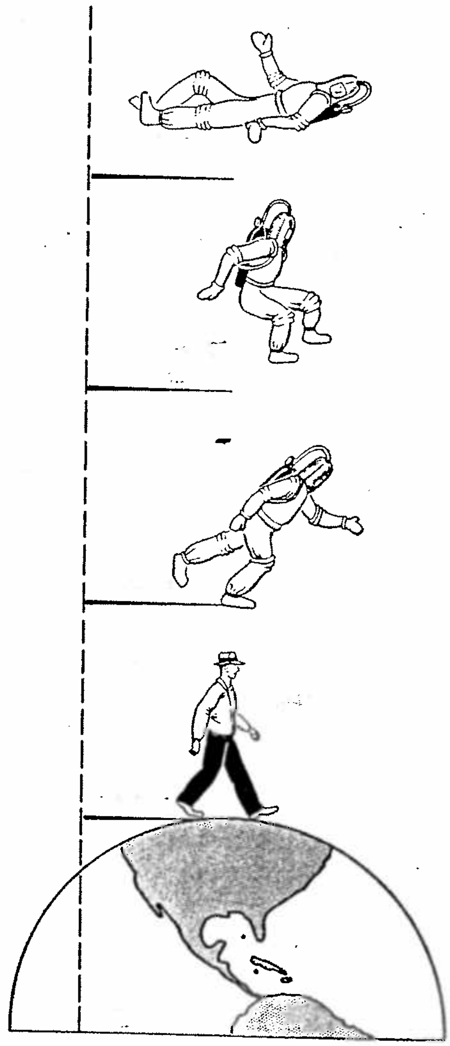
This learning element was developed by the UNIDO Leather Unit's staff, its experts and the consultants of the Clothing and Footwear Institute (UK) for the project US/PHI/85/109 and is a part of a complete Footwear Industry Certificate course. The material is made available to other UNIDO projects and may be used by UNIDO experts as training aid and given, fully or partly, as hand-out for students and trainees.

The complete Certificate Course includes the following learning elements:

Certificate course

-Feet and last
-Basic design
-Pattern cutting
-Upper clicking
-Closing
-Making
-Textiles and synthetic materials
-Elastomers and plastomers
-Purchasing and storing
-Quality determination and control
-Elements of physics
-General management
-Production management
-Industrial Law
-Industrial accountancy
-Electricity and applied mechanics
-Economics
-SI metric system of measurement
-Marketing
-Mathematics
-Elements of chemistry

FOOTWEAR AND LEATHERGOODS INDUSTRY CENTER
STAFF DEVELOPMENT PROGRAM



The SI Metric System of Measurement

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THE S.I. METRIC SYSTEM OF MEASUREMENT

A universal system of measurement, the SI (Systeme International) was adopted in 1960 and was gradually introduced to virtually all countries.

This system not only eliminates the ambiguities which prevail in the vast number of units of some past systems but also the elaborate conversion manipulations required in the international trade.

The reasons for the confusion in past systems are fundamentally the following:

1. Two or more basic units were used to measure the same concept.
2. A single unit was used to measure two or more different concepts.
3. The units were not consistent.

The SI Metric System does not have these pitfalls. It is a development of the mks (metre, kilogram, seconds) system with some differences.

1. Primary Units

The SI system is based on seven primary units:

QUANTITY	UNIT	SYMBOL
length	metre	m
mass	kilogram	kg
time	second	s
electric current	ampere	A
temperature*	kelvin**	K
luminous intensity	candela	cd
amount of substance	mole	mol

* temperature : thermodynamic or temperature difference

** Although the official unit of temperature is the kelvin, the celsius scale (sometimes referred to as centigrade) is used for convenience in many cases because the magnitude of the values is better suited to the more general applications. This become apparent when one realises that 0^{o} C (celsius) is equivalent to 273.15 K and 100^{o} C is equivalent to 373.15 K

2. Definitions of SI base units

metre : The metre is the length equal to 1 650 763.73 wave lengths in vacuum of the radiation corresponding to the transission between the levels $2p_{10}$ and $5d_5$ of the krypton 86 atom.

kilogram : is the unit of mass equal to the mass of the international prototype of the kilogram.

second : The second is the duration of 9 192 631 770 periods of the radiation corresponding to the transission between the two hyperfine levels of the ground state of the caesium-133 atom.

ampere : the ampere is that constant current which, if maintained in two straight parallel conductors of infinite length, of negligeable circular cross-section, and placed one meter apart in vacuum, would produce between these conductors a force equal to 2×10^{-7} newton per meter of length.

kelvin : the kelvin unit of thermodynamic temperature is the fraction $\frac{1}{273.16}$ of the thermodynamic temperature of the triple point of water.

When expressed in Celsius temperature (symbol t)

$$t = T - To \quad \text{where} \quad To = 273.15\ k$$

the unit degree "Celsius" (symbol ^{o}C) is used as special name for the kelvin.

candela : the candela is the luminous intensity, in the perpendicular direction, of a surface of $\frac{1}{600,000}$ square metre of a black body at the temperature of freezing platinum under pressure of 101 325 newtons per square meter.

mole : the mole is the amount of substance of a system which contains as many elementary entities as there are atoms in 0.012 kilogram of Carbon 12.

When the mole is used, the elementary entities must be specified and may be atoms, molecules, ions, electrons, other particles or specified groups of particles.

3. Decimal multiples and sub-multiples of SI units

Prefix	Symbol	Factor by which the unit is multiplied	
tera	T	10^{12}	
giga	G	10^{9}	
mega	M	10^{6}	1 million
kilo	k	10^{3}	1 thousand
hecto	h	10^{2}	
deca	da	10^{1}	ten
deci	d	10^{-1}	1 tenth
centi	c	10^{-2}	1 hundredth
milli	m	10^{-3}	1 thousandth
micro	μ	10^{-6}	
nano	n	10^{-9}	
pico	p	10^{-12}	
femto	f	10^{-15}	
atto	a	10^{-18}	

examples : 1 kilometre is equal to 1 thousand metres
1 millimetre is equal to 1 thousandth of a meter

note : one Ångström Å 10^{-10}
Water molecules are about 3 Å in diametre.

The favoured multiples and sub-multiples of the primary units increase or decrease in positive or negative powers of 3.
e.g. 10^{3} (kilo), 10^{6} (mega) 10^{9} (giga) - 10^{-3} 10^{-6} 10^{-9}
This explain the reason for discouraging the use of the prefixes deci and centi.

4. SI supplementary and derived units

Apart from the basic units of measurement there are also a large number of supplementary and derived units, only those which are regularly used when expressing the performances of shoe components are given here

Table SI gives the all set of derived units

Quantity	Name	Symbol	Relationship
Force	newton	N	$1\ N = 1\ \frac{kg\ m}{s^2}$
Pressure, stress	pascal	Pa	$1\ Pa = 1\ \frac{N}{m^2} = 1\ \frac{kg}{m\ s^2}$
Work, energy	joule	J	$1\ J = 1\ N\ m = 1\ \frac{kg\ m^2}{s^2}$
Mass per unit of length	tex	tex	$10^{-6}\ \frac{kg}{m}$ $1\ \frac{mg}{m}$

DEFINITIONS

newton N

The unit of force is the newton.

The newton is that force which, when acting on a body of mass one kilogram, gives it an acceleration equal to one metre per second at the square

or

The newton is the force required to accelerate a mass of one kilogram at a velocity of one meter per second each second (kg/m/s/s)

In other wor ds if the force of one newton is constantly applied to a body having a mass of one kilogram, after one second the body will have travelled one meter (velocity one meter per second), after two seconds it would have travelled a further two meters (velocity : two meters per second) and after three seconds it would have travelled a further three meters i.e. a total of six meters (velocity : three meters per second) etc.

Formerly and still frequently, the unit mass (kilogram) is erroneously used to measure force.

This is incorrect and even the term kilogram force (kgf) is considered to be an unsatisfactory compromise and is not acceptable.

Indeed, the kilogram force (kgf) is that force which, when acting on a body of mass one kilogram gives it an accelaration equal to that of the standard gravity.

As "standard gravity" is not constant, the use of it will give inconsistent results. In given conditions, one kilogram force will be equal to 9.80665 newton.

pascal

The pascal (Pa) is a measure of force per unit area, or more specifically it is the force of one newton applied evenly and perpendicularly over an area of one square meter (N/m^2)

It is used as unit of pressure, e.g. with the prefix kilo it is used to measure motorcar tyre pressures (KPa). It is also used to express elastic moduli and tensile strength.

On shoe materials tensile strength is expressed as megapascals (MPa) which are of course equivalent to meganewtons per square meter (MN/m^2)

Megapascals are also used to express the pressure in burst strength.

joule

A joule (J) is the work done when the point of application of a force of one newton is displaced through a distance of one meter in the direction of the force (N/m). This replaces the meter/kilogram in the previous system or the foot/pound in the Imperial system.

This units are used to measure the energy required to produce collapse when impacting domes formed from toe puff materials and also the impact strength of shank and steel reinforced toecaps

tex

This term is not used generally in the SI system but is confined to the textile industry. It is the mass in milligram of one meter of thread (mg/m). The submultiple, decitex (d tex), is normally used in test reports.

$$1 \text{ tex} = 10^{-6} \frac{kg}{m} = 1 \frac{g}{km} = 1 \frac{mg}{m}$$

NOTE

All units and prefixes when they appear unabbreviated are written entirely in lower casement e.g. newton, pascal, meter, etc. and the prefixes mega-, kilo-, milli-, etc. when used, are written attached to the unit, e.g. meganewton, kilopascal, millimeter, etc.

Certain units and prefixes when abbreviated commence with a capital letter. All units which fall into this category are derived from names of scientists

newton	(N)	Isaac Newton
pascal	(Pa)	Blaise Pascal
joule	(J)	James Joule
celsius	(C)	Anders Celsius
volt	(V)	Allessandro Volta
watt	(W)	James Watt
kelvin	(K)	William Kelvin

Units having other derivations are written only in lower casement; meter (m), second (s), gram (g), candela (c), radian (rad)

Prefixes which are multiples greater than kilo- commence with a capital letter in the abbreviated form; G (giga-), M(mega-), whilst kilo- and smaller submultiples appear only in lower casement; k (kilo), c (centi-), m (milli-)

Where units are combined, prefixes should occur in the numerator and not in the denominator, e.g. the expression N/mm^2 is discouraged and should be written MN/m^2 or to simplify further as MPa (since $Pa = N/m^2$)

TABLE SI

SI DERIVED UNITS

QUANTITY	SI UNIT NAME	SI UNIT SYMBOL	RELATIONSHIP
plane angle	radian	rad	$1 \text{ rad} = 1 \frac{m}{m}$
solid angle	steradian	sr	$1 \text{ sr} = 1 \frac{m^2}{m^2}$
frequency of a periodic accurance	hertz	Hz	$1 \text{ Hz} = \frac{1}{s}$
Activity of a radioactive substance	becquerel	Bq	$1 \text{ Bq} = \frac{1}{s}$
force	newton	N	$1 \text{ N} = 1 \frac{kg\ m}{s^2}$
pressure mechanical stress	pascal	Pa	$1 \text{ Pa} = 1 \frac{N}{m^2} = 1 \frac{kg}{m\ s^2}$
energy, work, quantity of heat	joule	J	$1 \text{ J} = 1 \text{ N m} = 1 \frac{kg\ m^2}{s^2} = 1 \text{ W s}$
power, heat flow	watt	W	$1 \text{ W} = 1 \frac{J}{s} = 1 \frac{N\ m}{s} = 1 \text{ V A}$
energy dosage	gray	Gy	$1 \text{ Gy} = 1 \frac{J}{kg} = 1 \frac{m^2}{s^2}$
electric charge quantity of electricity	coulomb	C	$1 \text{ C} = 1 \text{ A s}$
electric potential potential diff. electromotive for	volt	V	$1 \text{ V} = 1 \frac{J}{C} = 1 \frac{W}{A}$
electric capacity	farad	F	$1 \text{ F} = 1 \frac{C}{V} = 1 \frac{A\ s}{V}$
electric resistance	ohm	Ω	$1 \quad = 1 \frac{V}{A} = \frac{1}{S}$

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QUANTITY	SI UNIT NAME	SI UNIT SYMBOL	RELATIONSHIP
electric conductance	siemens	S	$1\ S = \frac{1}{\Omega} = 1\ \frac{A}{V}$
magnetic flux	weber	Wb	$1\ Wb = 1\ V\ s$
magnetic flux density, magn. induction	tesla	T	$1\ T = 1\ \frac{Wb}{m^2}$
inductance magn. conduct.	henry	H	$1\ H = 1\ \frac{Wb}{A} = 1\ \frac{V\ s}{A}$
celsius temperature	degree celsius	^{o}C	
luminous flux	lumin	lm	
illuminance	lux	lx	$1\ lx = \frac{1\ lm}{m^2}$