

CUSTOMER SUPPORT NOTE

Units issues and units of some common LUSAS inputs

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This support note is issued as a guideline only.



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1. Introduction

When creating a new model it is necessary to choose a system of units to be taken as the model units.

The system of units selected will be used for the modelling, attribute definitions and results processing so it is useful to use units appropriate to the type of analysis. Each system of units available for selection is a consistent set of units defining the units of force, length, mass, time and temperature respectively.

2. Description

2.1 Choosing a Suitable System of Units for the Model

A Bridge or Civil Engineer will generally prefer forces in units of kN or kips, and moments in units of kNm or kip-ft, so selecting the unit set **kN,m,t,s,C** or **kip,ft,slug,s,F** respectively would be appropriate. Where a detailed local analysis of a steel component for example, it might be more convenient to have stresses output in terms of MPa (N/mm^2) or ksi (klbf/in^2), so the unit set **N,mm,t,s,C** or **kip,in,kslinch,s,F** respectively, would be chosen in this case. For a thermal analysis where loading and results consist of energy terms rather than structural stresses, it is usually considered simpler to use the base SI units of **N,m,kg,s,C** or **N,m,kg,s,K**, so that the unit of energy is conveniently J (Nm or Kgm^2/s^2), the unit of power is W (J/s or Nm/s or Kgm^2/s^3) and unit of flux is $\text{J}/\text{m}^2\text{s}$ (Kg/s^3).

There are many metric and imperial systems of units available (as shown in the image on the following page), or the user can even choose assume their own consistent system of units and choose to leave the model “**Units unset**”.



2.2 Units for Some Common LUSAS Inputs

The following table gives the units for some common LUSAS inputs:

Entity	Common Units	Base SI Units	US Units
Acceleration	$m.s^{-2}$	$m.s^{-2}$	$in.s^{-2}$
Area	m^2	m^2	in^2
Bulk Modulus	$N.m^{-2}$	$kg.m^{-1}.s^{-2}$	ksi
Convection Heat Transfer Coefficient	$W.m^{-2}.K^{-1}$ or $J.m^{-2}.s^{-1}.K^{-1}$	$kg.s^{-3}.K^{-1}$	$kslinch.s^{-3}.^{\circ}F^{-1}$
Density	$kg.m^{-3}$	$kg.m^{-3}$	$kslinch.in^{-3}$
Displacement	m	m	in
Displacement (rotations)	rad	$m.m^{-1}$	rad
Energy	J	$kg.m^2.s^{-2}$	$kslinch.in^2.s^{-2}$
First Moment of Area	m^3	m^3	in^3
Flux (Total, CL)	W or $J.s^{-1}$	$kg.m^2.s^{-3}$	$Kslinch.in^2.s^{-3}$
Flux (Distributed, FLD)	$W.m^{-2}$ or $J.m^{-2}.s^{-1}$	$kg.s^{-3}$	$Kslinch.s^{-3}$
Force	N	$kg.m.s^{-2}$	kip
Length	m	m	in
Mass	kg	kg	kslinch
Moment	N.m	$kg.m^2.s^{-2}$	kip-in
Poisson's Ratio	[dimensionless]	[dimensionless]	[dimensionless]
Power	W or $J.s^{-1}$	$kg.m^2.s^{-3}$	$kslinch.in^2.s^{-3}$
Product Moment of Area	m^4	m^4	in^4
Radiation Heat Transfer Coefficient ¹	$W.m^{-2}.K^{-4}$ or $J.m^{-2}.s^{-1}.K^{-4}$	$kg.s^{-3}.K^{-4}$	$kslinch.s^{-3}.^{\circ}F^{-4}$
Rate of Internal Heat Generation (RIHG) ⁵	$W.m^{-3}$ or $J.m^{-3}.s^{-1}$	$kg.m^{-1}.s^{-3}$	$kslinch.in^{-1}.s^{-3}$
Second Moment of Area	m^4	m^4	in^4
Specific Heat Capacity ²	$J.kg^{-1}.K^{-1}$	$m^2.s^{-2}.K^{-1}$	$in^2.s^{-2}.^{\circ}F^{-1}$
Specific Heat Coefficient (Volumetric Heat Capacity) ²	$J.m^{-3}.K^{-1}$	$kg.m^{-1}.s^{-2}.K^{-1}$	$kslinch.in.s^{-2}.^{\circ}F^{-1}$
Spring stiffness	$N.m^{-1}$	$kg.s^{-2}$	$kip.in^{-1}$
Strain	[dimensionless]	[dimensionless]	[dimensionless]
Stress	$N.m^{-2}$	$kg.m^{-1}.s^{-2}$	ksi
Temperature	K	K	$^{\circ}F$
Thermal Conductivity ⁴	$W.m^{-1}.K^{-1}$ or $J.m^{-1}.s^{-1}.K^{-1}$	$kg.m.s^{-3}.K^{-1}$	$kslinch.in.s^{-3}.^{\circ}F^{-1}$
Thermal Expansion Coefficient	K^{-1}	K^{-1}	$^{\circ}F^{-1}$
Time ³	s	s	s
Torsion Constant	$m^4.rad^{-1}$	m^4	$in^4.rad^{-1}$
Velocity	$m.s^{-1}$	$m.s^{-1}$	$in.s^{-1}$
Young's Modulus	$N.m^{-2}$	$kg.m^{-1}.s^{-2}$	ksi

¹ The radiation heat transfer coefficient required in LUSAS is equal to the emissivity of the material multiplied by the Stefan-Boltzmann constant.

² The thermal material property required in LUSAS is actually the 'Specific Heat Coefficient', which is defined as the Specific Heat Capacity of the material multiplied by the density and has units $J.m^{-3}.K^{-1}$. This is also known as the 'Volumetric Heat Capacity'.

³ If a creep analysis is carried out the unit of time in the model units is overridden by a time unit of days. For a HHC (Heat of Hydration of Concrete) analysis, the time unit of hours or days can be chosen in HHC material and this will override the unit of time in the model units.

⁴ In a HHC analysis where the time unit of days has been selected in the HHC material, the input units for Thermal conductivity are $J.m^{-1}.day^{-1}.K^{-1}$ ($kg.m.s^{-2}.day^{-1}.K^{-1}$).

⁵ In a HHC analysis where the time unit of days has been selected in the HHC material, the input units for RIHG are $J.m^{-3}.day^{-1}$ ($kg.m^{-1}.s^{-2}.day^{-1}$).

2.3 Model Units Conversion Example

Please note that from V14.8 onwards it will be possible to view the units for a particular property input in the user interface, and it will also be possible to enter a property input in a different type of units; Modeller will convert the value entered into the model units for you.

This example shows how you might convert a property input to model units manually.

The intended inputs are:

- Thermal Conductivity = 40W/m.K
- Specific Heat coefficient (Volumetric heat capacity) = 3.66E6 J/m³.K

The model units are kN,mm,t,s,C.

The conversion of units for the Thermal Conductivity input are as follows:

$$40 \frac{W}{m.K} = 40 \frac{Kg.m^2}{s^3} \times \frac{1}{m.K} = 40 \frac{Kg.m}{s^3.K} \text{ in base SI units}$$

Therefore:

$$40 \frac{Kg.m}{s^3.K} \times \frac{t}{1000Kg} \times \frac{1000mm}{m} \times \frac{K}{^{\circ}C} = 40 \frac{t.mm}{s^3.^{\circ}C} \text{ in model units}$$

The conversion of units for the Volumetric Heat Capacity input are as follows:

$$3.66 \times 10^6 \frac{J}{m^3.K} = 3.66 \times 10^6 \frac{Kg.m^2}{s^2} \times \frac{1}{m^3.K} = 3.66 \times 10^6 \frac{Kg}{m.s^2.K} \text{ in base SI units}$$

Therefore:

$$3.66 \times 10^6 \frac{Kg}{m.s^2.K} \times \frac{t}{1000Kg} \times \frac{m}{1000mm} \times \frac{K}{^{\circ}C} = 3.66 \frac{t}{mm.s^2.^{\circ}C} \text{ in model units}$$