Abaqus Consistent Units:

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Several of the commercially available Finite Element Analysis (FEA) software, such as Abaqus, have no built-in system of units. It is the user responsibility to input all data in consistent units. The software will not detect any use of inconsistent units and will still generate the results, which are going to be erroneous in such a case.

The Table below shows how to input the values of certain properties or quantities in the SI system. Most FEM analysts are more familiar with the consistent units associated with having the base units being in [m (meter), N (Newton), s (second), K (Kelvin)] for the problem dimensions, loading, time, and temperature, respectively. However, when the problem geometry is created in units of mm (millimeters), things become a bit tricky.

Quantity	**Example**	**SI (m)**	**SI (mm)**
Mass	1000 kg	1000	1
Stress	120 MPa	120×10^{6}	120
Modulus of Elasticity	$207\ \mathrm{GPa}$	207×10^{9}	207×10^{3}
Energy	1.2 J	1.2	1200
Density	$7850\ \frac{\mathrm{kg}}{\mathrm{m}^3}$	7850	7850×10^{-12}
Specific Heat Capacity	$900\ \frac{\mathrm{J}}{\mathrm{kg.K}}$	900	900×10^{6}
Heat Flux	$152\ \frac{\mathrm{W}}{\mathrm{m}^2}$	152	152×10^{-3}
Stefan-Boltzmann Constant	$5.67 \times 10^{-8}\ \frac{\mathrm{W}}{\mathrm{m}^2.\mathrm{K}^4}$	5.67×10^{-8}	5.67×10^{-11}
Gravitational Constant	$9.81\ \frac{\mathrm{m}}{\mathrm{s}^2}$	9.81	9.81×10^{3}
Thermal Conductivity	$167\ \frac{\mathrm{W}}{\mathrm{m.K}}$	167	167

In the following examples, you will see the reasoning behind the values in the table.

Example (1):

If the dimensions were in millimeters (mm), time in seconds (s), and force in Newtons (N), you would need to input the modulus of elasticity for carbon steel in ABAQUS as $207\ \times 10^3$. This can be justified according to the following operations:

$$207\ \text{GPa} = 207 \times 10^9\ \text{Pa}$$

$$207\ \text{GPa} = 207 \times 10^9\ \frac{\text{N}}{\text{m}^2}$$

$$207\ \text{GPa} = 207 \times 10^9\ \frac{\text{N}}{\text{m}^2} \times \left(\frac{1\ \text{m}}{1000\ \text{mm}}\right)^2$$

$$207\ \text{GPa} = 207 \times 10^9\ \frac{\text{N}}{\text{m}^2} \times \frac{10^{-6}\ \text{m}^2}{\text{mm}^2}$$

$$207\ \text{GPa} = 207\ \times 10^3\ \frac{\text{N}}{\text{mm}^2}$$

Now the modulus of elasticity is expressed only in terms of the base units [mm, N, s, K].

Note that ($1\,\frac{\text{N}}{\text{mm}^2}$) is equivalent to (1 MPa).

Example (2):

If the dimensions were in millimeters (mm), time in seconds (s), and force in Newtons (N), you would need to input the density for carbon steel in ABAQUS as 7850×10^{-12}. This can be justified according to the following operations:

$$7850\ \frac{\mathrm{kg}}{\mathrm{m}^3} = 7850\ \frac{\left[\frac{\mathrm{N}}{\left(\frac{\mathrm{m}}{\mathrm{s}^2}\right)}\right]}{\left[\frac{\mathrm{m}^3}{1}\right]}$$

Note that mass [kg] = force [N] / acceleration [m/s^2]

$$7850\ \frac{\mathrm{kg}}{\mathrm{m}^3} = 7850\ \frac{\mathrm{N.s}^2}{\mathrm{m}^4}$$

$$7850\ \frac{\mathrm{kg}}{\mathrm{m}^3} = 7850\ \frac{\mathrm{N.s}^2}{\mathrm{m}^4} \times \left(\frac{1\ \mathrm{m}}{1000\ \mathrm{mm}}\right)^4$$

$$7850\ \frac{\mathrm{kg}}{\mathrm{m}^3} = 7850\ \frac{\mathrm{N.s}^2}{\mathrm{m}^4} \times \frac{10^{-12}\ \mathrm{m}^4}{\mathrm{mm}^4}$$

$$7850\ \frac{\mathrm{kg}}{\mathrm{m}^3} = 7850\ \times 10^{-12}\ \frac{\mathrm{N.s}^2}{\mathrm{mm}^4}$$

Now the density is expressed only in terms of the base units [mm, N, s, K].

Note that ($1\,\frac{\mathrm{N.s}^2}{\mathrm{mm}^4}$) is equivalent to ($1\,\frac{\mathrm{tonne}}{\mathrm{mm}^3}$).

Example (3):

If the dimensions were in millimeters (mm), time in seconds (s), and force in Newtons (N), you would need to input the specific heat capacity for aluminum in ABAQUS as 900×10^6. This can be justified according to the following operations:

$$900\ \frac{\mathrm{J}}{\mathrm{kg.K}} = 900\frac{\mathrm{N.m}}{\mathrm{kg.K}}$$

$$900\ \frac{\mathrm{J}}{\mathrm{kg.K}} = 900\frac{\frac{\mathrm{N.m}}{1}}{\left[\frac{\mathrm{N}}{\left(\frac{\mathrm{m}}{\mathrm{s}^2}\right)}\right].\mathrm{K}}$$

Note that mass [kg] = force [N] / acceleration [m/s^2]

$$900\ \frac{\mathrm{J}}{\mathrm{kg.K}} = 900\frac{\mathrm{N.m}\left(\frac{\mathrm{m}}{\mathrm{s}^2}\right)}{\mathrm{N.K}}$$

$$900\ \frac{\mathrm{J}}{\mathrm{kg.K}} = 900\frac{\mathrm{m}^2}{\mathrm{s}^2.\mathrm{K}}$$

$$900\ \frac{\mathrm{J}}{\mathrm{kg.K}} = 900\frac{\mathrm{m}^2}{\mathrm{s}^2.\mathrm{K}} \times \left(\frac{1000\ \mathrm{mm}}{1\ \mathrm{m}}\right)^2$$

$$900\ \frac{\mathrm{J}}{\mathrm{kg.K}} = 900 \times 10^6\frac{\mathrm{mm}^2}{\mathrm{s}^2.\mathrm{K}}$$

Now the specific heat capacity is expressed only in terms of the base units [mm, N, s, K].

Note that ($1\,\frac{\mathrm{mm}^2}{\mathrm{s}^2.\mathrm{K}}$) is equivalent to ($1\,\frac{\mathrm{mJ}}{\mathrm{tonne.K}}$).