"Is there a convert command that converts a matrix to a tensor"

First of all, even working with matrices, you are working in some *space* and, in general, using some coordinates, and if working with tensors you use certain type of letters as *tensor indices*. Suppose it is a 3D Euclidean space, your coordinates are Cartesian, and you want to use lowercase letters as indices; set that:

The dimension and signature of the tensor space are set to [3,(+++)]

Systems of spacetime coordinates are $:\{X = (x, y, z)\}$

The Euclidean metric in coordinates $[x, y, z]$

$$g_{\mu,\nu} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

$$\begin{aligned}&[\mathit{coordinatesystems} = \{X\}, \mathit{dimension} = 3,\\ &\quad \mathit{metric} = \{(1,1) = 1, (2,2) = 1, (3,3) = 1\},\\ &\quad \mathit{spacetimeindices} = \mathit{lowercaselatin}]\end{aligned} \tag{1}$$

Suppose you have the matrix

$$\begin{bmatrix} m_{1,1} & m_{1,2} & m_{1,3} \\ m_{2,1} & m_{2,2} & m_{2,3} \\ m_{3,1} & m_{3,2} & m_{3,3} \end{bmatrix} \tag{2}$$

To transform it into a tensor, just use the Define command

Defined objects with tensor properties

$$\{\gamma_{a}, M_{i,j}, \sigma_{a}, \partial_{a}, g_{a,b}, \epsilon_{a,b,c}, X_{a}\} \tag{3}$$

That is all. You can perform all tensor computations with such so defined tensor $M_{i,j}$. Start with its definition

$$M_{i,j} = \begin{bmatrix} m_{1,1} & m_{1,2} & m_{1,3} \\ m_{2,1} & m_{2,2} & m_{2,3} \\ m_{3,1} & m_{3,2} & m_{3,3} \end{bmatrix} \tag{4}$$

Then itscomponents (default is the *covariant* ones)

$$M_{a,b} = \begin{bmatrix} m_{1,1} & m_{1,2} & m_{1,3} \\ m_{2,1} & m_{2,2} & m_{2,3} \\ m_{3,1} & m_{3,2} & m_{3,3} \end{bmatrix} \tag{5}$$

The *contravariant* components are the same as the covariant ones because the space is Euclidean

$$M^{a,b} = \begin{bmatrix} m_{1,1} & m_{1,2} & m_{1,3} \\ m_{2,1} & m_{2,2} & m_{2,3} \\ m_{3,1} & m_{3,2} & m_{3,3} \end{bmatrix} \tag{6}$$

The trace

$$m_{1,1} + m_{2,2} + m_{3,3} \tag{7}$$

Also via

$$M_{j,j} \tag{8}$$

$$m_{1,1} + m_{2,2} + m_{3,3} \tag{9}$$

The determinant

$$\begin{aligned} & m_{1,1}m_{2,2}m_{3,3} - m_{1,1}m_{2,3}m_{3,2} - m_{1,2}m_{2,1}m_{3,3} \\ & + m_{1,2}m_{2,3}m_{3,1} + m_{1,3}m_{2,1}m_{3,2} - m_{1,3}m_{2,2}m_{3,1} \end{aligned} \tag{10}$$

The inert representation of this determinant

$$|\ \mathrm{M}| \tag{11}$$

$$\begin{aligned} & m_{1,1}m_{2,2}m_{3,3} - m_{1,1}m_{2,3}m_{3,2} - m_{1,2}m_{2,1}m_{3,3} \\ & + m_{1,2}m_{2,3}m_{3,1} + m_{1,3}m_{2,1}m_{3,2} - m_{1,3}m_{2,2}m_{3,1} \end{aligned} \tag{12}$$

The non-zero components

$$\begin{aligned} M_{a,b} = \{ & (1,1) = m_{1,1}, (1,2) = m_{1,2}, (1,3) = m_{1,3}, (2,1) = m_{2,1}, (2,2) = m_{2,2}, \\ & (2,3) = m_{2,3}, (3,1) = m_{3,1}, (3,2) = m_{3,2}, (3,3) = m_{3,3} \} \end{aligned} \tag{13}$$

*"for example to perform basic operations like omega*J*omega where J is the inertia tensor and omega the vector of angular velocity?"*

OK. Define your *vector* now. You can do that directly with Define, or also starting with a Maple *Vector* constructor

$$\begin{bmatrix} v_1 \\ v_2 \\ v_3 \end{bmatrix} \tag{14}$$

Defined objects with tensor properties

$$\{\gamma_a, M_{i,j}, \sigma_a, V_j, \partial_a, g_{a,b}, \epsilon_{a,b,c}, X_a\} \tag{15}$$

For example, the computation you asked for

$$V_i M_{i,j} V_j \tag{16}$$

$$m_{1,1}v_1^2 + m_{1,2}v_1v_2 + m_{1,3}v_1v_3 + m_{2,1}v_1v_2 + m_{2,2}v_2^2 + m_{2,3}v_2v_3 + m_{3,1}v_1v_3 + m_{3,2}v_2v_3 + m_{3,3}v_3^2 \tag{17}$$

Another example: operations with the metric

$$V_a g_{a,i} M_{i,j} g_{b,j} V_b \tag{18}$$

$$V_i M_{i,j} V_j \tag{19}$$

Or products of tensor (underlying matrices) that take the symmetry properties into account

$$\epsilon_{a,b,c} V_a V_b \tag{20}$$

$$0 \tag{21}$$

Or other tensor commands

$$\frac{M_{a,b}}{2} + \frac{M_{b,a}}{2} \tag{22}$$

$$\frac{M_{a,b}}{2} - \frac{M_{b,a}}{2} \tag{23}$$

Display components using Physics:-TensorArray

$$V_i M_{i,j} \tag{24}$$

$$\left[\; m_{1,1}v_1 + m_{2,1}v_2 + m_{3,1}v_3 \quad m_{1,2}v_1 + m_{2,2}v_2 + m_{3,2}v_3 \quad m_{1,3}v_1 + m_{2,3}v_2 + m_{3,3}v_3 \;\right] \tag{25}$$

$$V_k M_{i,j} \tag{26}$$

$$V_k M_{i,j} \left(\textit{ordering of free indices } = [i, j, k]\right) \tag{27}$$

For all these and more check the large help page (sort-of-manual) (Physics:-Tensors

A note on the working space: *Physics* implements working with several different spaces simultaneously (space + spacetime + ...) - just use different kind of indices for each type of space, and there one kind of space that is *generic*, which means: *arbitrary-symbolic dimension* (all the other spaces have specific integer dimension). The metric of such a *generic* space is Euclidean and represented by Physics:-KroneckerDelta

$$[genericindices = greek] \tag{28}$$

Defined objects with tensor properties

$$\{A_{\mu}, B_{\mu}, C_{\mu,\nu}, \gamma_{a}, M_{i,j}, \sigma_{a}, U_{a,b,c}, V_{j}, \partial_{a}, g_{a,b}, \epsilon_{a,b,c}, X_{a}\} \tag{29}$$

$$C_{\mu,\nu} - C_{\nu,\mu} \tag{30}$$

$$0 \tag{31}$$