# METR4202 -- Robotics
# Tutorial 2 – Week 2: Homogeneous Coordinates

The objective of this tutorial is to explore homogenous transformations. The MATLAB robotics toolbox developed by Peter Corke might be a useful aid[1] (remember to run `strartup_rvc`).

Please answer the tutorial by Thursday night via the Platypus system for tutor/peer feedback.

## Reading

Please read/review Section 2.4 of *Multiple View Geometry in Computer Vision* (see attached).
(from R. Hartley and A. Zisserman. *Multiple View Geometry in Computer Vision*. Cambridge University Press, 2004)

## Review

The Homogeneous Transformations functions in the toolbox are useful.

1. Try the Transformations module of `rtbdemo` for a demonstration of these function
2. Look at rpy2tr and tr2rpy (`doc rpy2tr` and `doc tr2rpy`)
3. Look at the source of these functions (`open rpy2tr` and `open tr2rpy`). Does `tr2rpy` exploit the redundancies inherent in a rotation matrix?

## Questions

1. Calculate the homogeneous transformation matrix ${}^{A}_{B}T$ given the translations (${}^{A}\boldsymbol{P}_{B}$) and the roll-pitch-yaw rotations (as α-β-γ) applied in the order yaw, pitch, roll. **[20%]**

    a. $\alpha=10°$, $\beta=20°$, $\gamma=30°$, ${}^{A}\boldsymbol{P}_{B}=\{1\ \ 2\ \ 3\}^{\mathbf{T}}$
    b. $\alpha=10°$, $\beta=30°$, $\gamma=30°$, ${}^{A}\boldsymbol{P}_{B}=\{3\ \ 0\ \ 0\}^{\mathbf{T}}$

2. Compare the output of: $\alpha=90°$, $\beta=180°$, $\gamma=-90°$, ${}^{A}\boldsymbol{P}_{B}=\{0\ \ 0\ \ 1\}^{\mathbf{T}}$ and $\alpha=90°$, $\beta=180°$, $\gamma=270°$, ${}^{A}\boldsymbol{P}_{B}=\{0\ \ 0\ \ 1\}^{\mathbf{T}}$ **[10%]**

3. Given the following 3x3 rotation matrices: **[40%]**

$$R_1=\begin{bmatrix} 0.7500 & -0.4330 & -0.5000 \\ 0.2165 & 0.8750 & -0.4330 \\ 0.6250 & 0.2165 & 0.7500 \end{bmatrix},\ R_2=\begin{bmatrix} 0.6399 & -0.2351 & -0.6159 \\ 0.2860 & 0.5854 & -0.4970 \\ 0.3221 & 0.2488 & 0.7132 \end{bmatrix},$$

$$R_3=\begin{bmatrix} 0 & 0 & 1 \\ 0.8660 & 0.5000 & 0 \\ -0.500 & 0.8660 & 0 \end{bmatrix},\ R_4=\begin{bmatrix} 0.0238 & 0.1524 & 0.9880 \\ -0.3030 & -0.9407 & 0.1524 \\ 0.9527 & -0.3030 & 0.0238 \end{bmatrix}$$

    a. Are these (within practical numerical limits) valid rotation matrices? Why?

    b. If yes, determine the Roll, Pitch, and Yaw that define each matrix. Do you believe their values?

[1] http://petercorke.com/Robotics_Toolbox.html