# Exercise 5 – Transformations Part 2

Matrices should be notated like so: $\begin{bmatrix} a & b & c & d \\ e & f & g & h \\ i & j & k & l \\ m & n & o & p \end{bmatrix}$

**Calculators are permitted.**

## 1. TRS

a) What order do we perform the TRS operations in? Is it **scaling first, rotation second, translation third** OR **translation first, rotation second, scaling third**?

b) Explain briefly why we need to transform in this specific order?

c) How do we combine translation (**T**), rotation (**R**) and scaling (**S**) into a single matrix **M**? Show the formula below.

d) Calculate **M** given the matrices below:

**T** = $\begin{bmatrix} 1 & 0 & 0 & 5 \\ 0 & 1 & 0 & 3 \\ 0 & 0 & 1 & 2 \\ 0 & 0 & 0 & 1 \end{bmatrix}$ **R** = $\begin{bmatrix} 0 & 0 & 1 & 0 \\ 0 & 1 & 0 & 0 \\ -1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$ **S** = $\begin{bmatrix} 2 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$

**M** =

## 2. Inverse Transformations

a) Transforming a vertex is the process of multiplying a matrix by a vertex in **model space** to transform it into **world space**. So what exactly does an Inverse Transformation do?

b) $\mathbf{M}^{-1}$ is an inverse of Matrix **M**. What is the formula for defining $\mathbf{M}^{-1}$?

c) Given the following matrices, calculate the **inverse of M** ($\mathbf{M}^{-1}$)?

$$\mathbf{T} = \begin{bmatrix} 1 & 0 & 0 & 5 \\ 0 & 1 & 0 & 3 \\ 0 & 0 & 1 & 2 \\ 0 & 0 & 0 & 1 \end{bmatrix} \quad \mathbf{R} = \begin{bmatrix} 0 & 0 & 1 & 0 \\ 0 & 1 & 0 & 0 \\ -1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \quad \mathbf{S} = \begin{bmatrix} 2 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$\mathbf{M}^{-1}$ =