This worksheet is split into two sections: Part A is a set of “traditional” maths questions to complete without a computer, while Part B involves using code to answer the same or similar questions. You can complete either section first, or swap between them; you may find that tackling the same problem using a different approach enhances your understanding of it.

# Part A

Answer the following questions using pen(cil) and (graph) paper.

Pro tip: show your working – diagrams can be helpful!

1. For each of the pairs of vectors below, evaluate their dot product using the algebraic definition:  
   and check the result against your answers to question 3 of part A of last week’s exercises using the identity  
   1. and
   2. and
2. Write down any two vectors that are (i) parallel and (ii) perpendicular to:

Verify that your answers are correct using the dot product.

1. Compute the following matrix products:

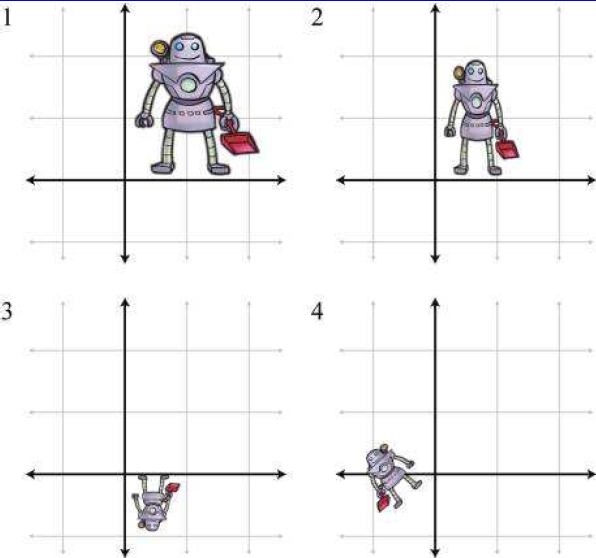
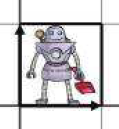
What do you notice about (c)? How about (b) and (e)?

Exercises may include some modified questions from

*3D Math Primer for Graphics and Game Development*,

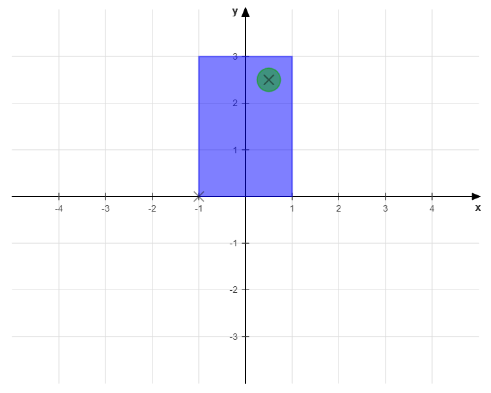
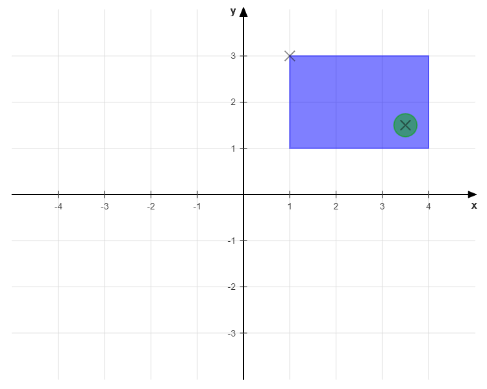
Fletcher Dunn and Ian Parberry, CRC Press

1. Describe the transformation represented by each of the following matrices.  
   Hint: consider what happens when they are applied to the *basis vectors* and
2. Match each of the following figures (1-4) with their corresponding transformations as applied to the figure on the left:



Figures taken from *3D Math Primer for Graphics and Game Development*,

Fletcher Dunn and Ian Parberry, CRC Press

1. Compute the inverses of the matrices in question 4 using the formula
2. You may have noticed that a class of transformation is missing from the examples above: translation. This requires the use of *homogeneous coordinates*, where the point is represented by so that it can be multiplied by a 3x3 matrix, .
   1. Write the displacement from the origin to the point as a homogeneous column vector.
   2. Write down the homogeneous matrix to describe a 2D translation of 1 unit in the direction and 2 units in , and apply it to the vector in part (a).
   3. Combine your matrix from part (b) with an appropriate rotation matrix to represent the following transformation:  
      →  
      What happens if you reverse the order in which you combine the matrices?

# Part B

We’re going to carry on using the same program as before for this section; make sure you have completed at least the first two questions from part B of last week’s exercises, as you’ll need the functionality in order to do this week’s.