Graphics 2
Matrix and vector operations
Non-assessed exercise

This exercise is to develop practical skills in matrix and vector operations (see handout *Mathematical Tools for Computer Graphics*).

The solutions will be available on 17th January at:
http://www.cs.bham.ac.uk/~exc/Teaching/Graphics/

Matrix operations
Let:

$$A = \begin{bmatrix} 3 & 2 \\ 4 & 1 \end{bmatrix} \quad B = \begin{bmatrix} 0 & -2 \\ 4 & 5 \end{bmatrix} \quad C = \begin{bmatrix} 4 & 1 & 0 \\ 1 & 3 & 2 \\ 0 & 2 & 5 \end{bmatrix} \quad D = \begin{bmatrix} 2 \\ 1 \\ 4 \end{bmatrix} \quad E = [\ 9\ \ 0\ \ 5\ ]$$

Calculate the following expressions or give reasons why the are undefined:

1.	A + B		8.	B * A
2.	B + A		9.	A * D
3.	C + D		10.	C * D
4.	C + E		11.	D * C
5.	3E		12.	E * C
6.	2A + B		13.	D * E
7.	A * B		14.	E * D

Vector operations
Let:

$\bar{a} = [\ 1\ \ 1\ \ 0\ ] \quad \bar{b} = [\ -1\ \ 2\ \ 0\ ] \quad \bar{c} = [\ 2\ \ 3\ \ 1\ ] \quad \bar{d} = [\ 5\ \ -7\ \ 2\ ] \quad \bar{e} = [\ 7\ \ -7\ \ 1\ ]$

Calculate the following expressions:

15.	$3 \cdot \bar{a}$		21.	$\bar{c} \cdot \bar{d}$
16.	$-2 \cdot \bar{c}$		22.	$\bar{a} \times \bar{b}$
17.	$\bar{a} + \bar{b}$		23.	$\bar{b} \times \bar{a}$
18.	$\bar{c} - \bar{d}$		24.	$\bar{a} \times \bar{c} + \bar{c} \times \bar{a}$
19.	$\bar{a} \cdot \bar{b}$		25.	$\bar{a} \times \bar{e}$
20.	$\bar{b} \cdot \bar{a}$			

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SOLUTIONS

Matrix operations

$$A = \begin{bmatrix} 3 & 2 \\ 4 & 1 \end{bmatrix} \quad B = \begin{bmatrix} 0 & -2 \\ 4 & 5 \end{bmatrix} \quad C = \begin{bmatrix} 4 & 1 & 0 \\ 1 & 3 & 2 \\ 0 & 2 & 5 \end{bmatrix} \quad D = \begin{bmatrix} 2 \\ 1 \\ 4 \end{bmatrix} \quad E = \begin{bmatrix} 9 & 0 & 5 \end{bmatrix}$$

1. $A + B = \begin{bmatrix} 3 & 0 \\ 8 & 6 \end{bmatrix}$

2. $B + A = \begin{bmatrix} 3 & 0 \\ 8 & 6 \end{bmatrix}$

3. $C + D$ Undefined, matrices have to be of the same size

4. $C + E$ Undefined, matrices have to be of the same size

5. $3E = \begin{bmatrix} 27 & 0 & 15 \end{bmatrix}$

6. $2A + B = \begin{bmatrix} 6 & 2 \\ 12 & 7 \end{bmatrix}$

7. $A * B = \begin{bmatrix} 8 & 4 \\ 4 & -3 \end{bmatrix}$

8. $B * A = \begin{bmatrix} -8 & -2 \\ 32 & 13 \end{bmatrix}$

10. $C * D = \begin{bmatrix} 9 \\ 13 \\ 22 \end{bmatrix}$

11. $D * C$ Undefined. The number of columns in the first matrix must be equal to the number of rows in the second matrix

12. $E * C = \begin{bmatrix} 36 & 19 & 25 \end{bmatrix}$

13. $D * E = \begin{bmatrix} 18 & 0 & 10 \\ 9 & 0 & 5 \\ 36 & 0 & 20 \end{bmatrix}$

14. $E * D = [\ 38\ ]$

Vector operations

$\bar{a} = [\ 1\ \ 1\ \ 0\ ]$ $\qquad \bar{b} = [\ -1\ \ 2\ \ 0\ ]$ $\qquad \bar{c} = [\ 2\ \ 3\ \ 1\ ]$ $\qquad \bar{d} = [\ 5\ \ -7\ \ 2\ ]$

15. $3\,\bar{a} = [\ 3\ \ 3\ \ 0\ ]$

16. $-2\,\bar{c} = [\ -4\ \ -6\ \ -2\ ]$

17. $\bar{a} + \bar{b} = [\ 0\ \ 3\ \ 0\ ]$

18. $\bar{c} - \bar{d} = [\ -3\ \ 10\ \ -1\ ]$

19. $\bar{a} \cdot \bar{b} = 1$

20. $\bar{b} \cdot \bar{a} = 1$

21. $\bar{c} \cdot \bar{d} = -9$

22. $\bar{a} \times \bar{b} = [\ 0\ \ 0\ \ 3\ ]$

23. $\bar{b} \times \bar{a} = [\ 0\ \ 0\ \ -3\ ]$

24. $\bar{a} \times \bar{c} + \bar{c} \times \bar{a} = [\ 0\ \ 0\ \ 0\ ]$

25. $\bar{a} \times \bar{e} = [\ 1\ \ -1\ \ -14\ ]$