Vector Algebra

Standard difficulty · 20 questions · 40 marks · Time: 36 minutes

Name: _____ Date: _____ Score: ____ / 40

Show your working for Sections B and C. Answers are on the last page — try every question first!

Section A — Choose the correct answer 8 × 1 = 8 marks

1. The magnitude of $3\hat{i} + 2\hat{j} - 6\hat{k}$ is:

(a) 7 **(b)** 49 **(c)** 11 **(d)** 8

2. If $a = -2\hat{i} - 5\hat{j} + 4\hat{k}$ and $b = -4\hat{i} - 4\hat{j} - \hat{k}$, then $a \cdot b$ is:

(a) 32 **(b)** −12 **(c)** −24 **(d)** 24

3. The unit vector in the direction of $-12\hat{i} - 12\hat{j} + \hat{k}$ is:

(a) $(1/17)(12\hat{i} + 12\hat{j} - \hat{k})$ **(b)** $(1/17)(-12\hat{i} - 12\hat{j} + \hat{k})$
(c) $(1/289)(-12\hat{i} - 12\hat{j} + \hat{k})$ **(d)** $(1/25)(-12\hat{i} - 12\hat{j} + \hat{k})$

4. If $a = \hat{i} - 3\hat{j} + 4\hat{k}$ and $b = 4\hat{i}$, then $a \times b$ is:

(a) $16\hat{i} + 12\hat{k}$ **(b)** $-16\hat{j} - 12\hat{k}$ **(c)** $16\hat{j} + 12\hat{k}$ **(d)** $4\hat{i}$

5. A quantity with both magnitude and direction is:

(a) an angle **(b)** a scalar **(c)** a ratio **(d)** a vector

6. The projection of $a = -4\hat{i} + \hat{j} + 3\hat{k}$ on $b = -6\hat{i} + 7\hat{j} - 6\hat{k}$ is:

(a) 13/11 **(b)** 13/121 **(c)** 13 **(d)** −13/11

7. The vectors $\lambda\hat{i} + 6\hat{j} - 4\hat{k}$ and $4\hat{i} + 4\hat{j} + \hat{k}$ are perpendicular when λ is:

(a) 5 **(b)** 20 **(c)** −4 **(d)** −5

8. Assertion (A): The vectors $6\hat{i} - 4\hat{j} + 2\hat{k}$ and $-32\hat{i} - 34\hat{j} + 28\hat{k}$ are perpendicular.
Reason (R): Two non-zero vectors are perpendicular when their vector product is zero.

(a) Both A and R are true, and R is the correct explanation of A.
(b) Both A and R are true, but R is not the correct explanation of A.
(c) A is true, but R is false.
(d) A is false, but R is true.

Section B — Short answer 8 × 2 = 16 marks

9. If $a = 3\hat{i} + \hat{j} + 5\hat{k}$ and $b = -\hat{i} + 3\hat{j} + 5\hat{k}$, find $a + b$, $a - b$ and $4a - 4b$.

10. Find the area of the parallelogram whose adjacent sides are $3\hat{i} + 2\hat{j} + 2\hat{k}$ and $-\hat{i}$.

11. Find the area of the triangle with vertices A(−5, −5, −3), B(5, 4, 2) and C(3, 2, 0).

12. Find the position vector of the point R dividing the join of P(−2î − ĵ + 2k̂) and Q(2î + 3ĵ + 2k̂) internally in the ratio 4 : 1.

13. Find the direction cosines of the vector −6î + 9ĵ + 2k̂.

14. Find the projection of −î + 2ĵ on 6î − 2ĵ − 9k̂.

15. If a = −4î − 2ĵ + k̂, b = −3î + 2ĵ − 5k̂ and c = −4î − 5ĵ + 2k̂, find λ such that a + λb is perpendicular to c.

16. Find a unit vector perpendicular to both 4î − 3ĵ − k̂ and −î − 3ĵ − 4k̂.

Section C — Word problems — 4 × 4 = 16 marks

17. Show that the points A(3, −1, 5), B(6, 1, 4) and C(1, 0, 1) form a right-angled triangle, and find its area.

18. Find the angle between a = 12î − 12ĵ − k̂ and b = −12î − 9ĵ − 8k̂.

19. The adjacent sides of a parallelogram are $a = 4\hat{j} + 2\hat{k}$ and $b = 2\hat{i} - 2\hat{j} + 4\hat{k}$. Find its diagonals and its area.

20. Vectors a, b and c satisfy $a + b + c = 0$, with $|a| = 10$, $|b| = 9$ and $|c| = 7$. Find $a \cdot b + b \cdot c + c \cdot a$.

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Answer key

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Q	Answer	Working
1	**(a) 7**	$\sqrt{(3^2 + 2^2 + (-6)^2)} = \sqrt{49}$
2	**(d) 24**	$(-2)(-4) + (-5)(-4) + 4(-1)$
3	**(b) $(1/17)(-12\hat{i} - 12\hat{j} + \hat{k})$**	divide by $\lvert a\rvert = 17$
4	**(c) $16\hat{j} + 12\hat{k}$**	expand the determinant $\begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ a_1 & a_2 & a_3 \\ b_1 & b_2 & b_3 \end{vmatrix}$
5	**(d) a vector**	—
6	**(a) 13/11**	$(a \cdot b)/\lvert b\rvert = 13/11$
7	**(d) −5**	$4\lambda + 6(4) + (-4)(1) = 0$
8	**(c) A is true, but R is false.**	A is true: their scalar product is 0. R is false.
9	**$a + b = 2\hat{i} + 4\hat{j} + 10\hat{k}$; $a - b = 4\hat{i} - 2\hat{j}$; $4a - 4b = 16\hat{i} - 8\hat{j}$**	add or subtract matching components
10	**$2\sqrt{2}$ square units**	$a \times b = -2\hat{j} + 2\hat{k}$; $\lvert a \times b\rvert = \sqrt{8}$
11	**$\sqrt{42}$ square units**	$AB \times AC = -8\hat{i} + 10\hat{j} - 2\hat{k}$; area = $\frac{1}{2}\sqrt{168}$
12	**$(6/5)\hat{i} + (11/5)\hat{j} + 2\hat{k}$**	$(p + 4q)/5$
13	**−6/11, 9/11, 2/11**	$\lvert a\rvert = 11$
14	**−10/11**	$a \cdot b = -10$, $\lvert b\rvert = 11$
15	**$\lambda = 7/2$**	$(a + \lambda b) \cdot c = 0 \Rightarrow 28 + (-8)\lambda = 0$
16	**$\pm(1/\sqrt{595})(9\hat{i} + 17\hat{j} - 15\hat{k})$**	$a \times b = 9\hat{i} + 17\hat{j} - 15\hat{k}$; divide by the length
17	**$AB = 3\hat{i} + 2\hat{j} - \hat{k}$, $AC = -2\hat{i} + \hat{j} - 4\hat{k}$; $AB \cdot AC = 0$, so the right angle is at A; area = $(7/2)\sqrt{6}$ square units**	$\lvert AB \times AC\rvert = \sqrt{294}$
18	**$\theta = \cos^{-1}(-28/289)$**	$a \cdot b = -28$, $\lvert a\rvert = 17$, $\lvert b\rvert = 17$; $\cos\theta = -28/289$
19	**diagonals $2\hat{i} + 2\hat{j} + 6\hat{k}$ and $-2\hat{i} + 6\hat{j} - 2\hat{k}$; area $4\sqrt{30}$ square units**	area = $\lvert a \times b\rvert$, $a \times b = 20\hat{i} + 4\hat{j} - 8\hat{k}$
20	**−115**	$\lvert a + b + c\rvert^2 = 0 \Rightarrow 100 + 81 + 49 + 2(a \cdot b + b \cdot c + c \cdot a) = 0$

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