1.10 Pure: Vectors

EDEXCEL 9MA0 · Calculator allowed · about 230 minutes · Write-in edition

Total Marks

Name: _____ Date: ____ / ____ / _____

Answer ALL questions. Show all your working.

1 p = 4i + j, q = -i + 5j. Find p + q.

(Total for Question 1 is 1 mark)

2 p = 4i + j, q = -i + 5j. Find p - q.

(Total for Question 2 is 1 mark)

3 The vector a = 3i - 4j.

(a) Find |a|. **(2)**

(b) Find the unit vector in the direction of a. **(2)**

(c) Given b = -2i + 5j, find a + 2b, and hence find |a + 2b|, giving your answer to 3 significant figures. **(4)**

(Total for Question 3 is 8 marks)

4 a = 5i - 12j. Find |a|.

(Total for Question 4 is 1 mark)

5 Find the value of k for which ki + 6j is parallel to 2i + 3j.

(Total for Question 5 is 1 mark)

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6 b = 8i + 6j. Find |b|.

(Total for Question 6 is 1 mark)

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7 Find the unit vector in the direction of 6i - 8j.

(Total for Question 7 is 1 mark)

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8 Relative to a fixed origin O, OA = 2i + 3j and OB = 7i - 9j. Find the vector AB.

(Total for Question 8 is 1 mark)

9 State whether the vectors 4i - 6j and -2i + 3j are parallel, giving a brief reason.

(Total for Question 9 is 1 mark)

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10 Relative to a fixed origin O, points P and Q have position vectors p = 2i + 3j and q = 8i - 3j. The point R lies on PQ such that PR : RQ = 2 : 1.

(a) Find the position vector of R. **(4)**

(b) A further point S has position vector s = 12i + 5j. Find the vector RS, and hence find a unit vector in the direction of RS. **(4)**

(Total for Question 10 is 8 marks)

11 Two survey points D and E have position vectors, relative to a fixed origin and measured in metres, OD = 2i - j + 4k and OE = 6i + 3j - 2k.

(a) Find the vector DE, and hence find |DE|, giving your answer in metres to 3 significant figures. **(4)**

(b) The point F lies on DE such that DF : FE = 3 : 1. Find the position vector of F. **(2)**

(c) State, with a reason, whether F lies closer to D or to E. **(1)**

(Total for Question 11 is 7 marks)

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12 a = 3i - 2j + 6k. Find |a|, and hence find the unit vector in the direction of a.

(Total for Question 12 is 2 marks)

13 p = 2i - 5j. q = ti + 15j, where t is a constant. Given that p and q are parallel, find the value of t.

(Total for Question 13 is 2 marks)

14 Relative to a fixed origin O, OA = 2i - 3j and OB = 8i + 7j. M is the midpoint of AB. Find the position vector of M.

(Total for Question 14 is 2 marks)

15 Relative to a fixed origin O, the points A and B have position vectors OA = 3i + j - 2k and OB = 7i - 3j + 6k. Find the vector AB, and hence find |AB|, giving your answer as an exact simplified surd.

(Total for Question 15 is 3 marks)

16 Two forces acting on a particle are F1 = (3i - 2j) N and F2 = (-7i + 9j) N. Find the resultant force, and its magnitude, giving your answer in newtons to 3 significant figures.

(Total for Question 16 is 3 marks)

17 Relative to a fixed origin O, points P and Q have position vectors OP = i + 4j - 3k and OQ = 9i - 4j + 5k. The point R lies on PQ such that PR : RQ = 3 : 1. Find the position vector of R.

(Total for Question 17 is 4 marks)

18 In triangle OAB, OA = a and OB = b. The point P lies on AB such that AP : PB = 1 : 2. The point Q lies on OP such that OQ : QP = 4 : 1.

(a) Find AB in terms of a and b, and hence find OP in terms of a and b. **(3)**

(b) Find OQ in terms of a and b. **(2)**

(c) Find AQ in terms of a and b, giving your answer in its simplest form. **(2)**

(Total for Question 18 is 7 marks)

19 Relative to a fixed origin O, the points A and B have position vectors OA = -3i + 2j + k and OB = i - j + 4k.

(a) Find the vector AB and the exact length |AB|. **(4)**

(b) Find the position vector of the midpoint M of AB. **(2)**

(c) The point C lies on the line AB, with AC = 2 AB. Find the position vector of C. **(2)**

(d) The point D has position vector 9i - 7j + 10k. Show that D lies on the line AB and find the ratio AD : AB. **(3)**

(Total for Question 19 is 11 marks)

20 The vectors a and b are given by $a = 7i + j$ and $b = i + j$.

(a) Find $a + 3b$, and its magnitude to 3 significant figures. **(4)**

(b) Find the angle that $a + 3b$ makes with the positive i direction, measured anticlockwise, to 1 decimal place. **(2)**

(c) Given that $a + \lambda b$ is parallel to j, find the value of λ. **(2)**

(Total for Question 20 is 8 marks)

21 Relative to a fixed origin O, the points A and B have position vectors $\overrightarrow{OA} = -4\mathbf{i} + 7\mathbf{j} + 8\mathbf{k}$ and $\overrightarrow{OB} = 3\mathbf{i} - 6\mathbf{j} + \mathbf{k}$.

(a) Find the vector AB and the exact length |AB|. **(4)**

(b) Find the position vector of the midpoint M of AB. **(2)**

(c) The point C lies on the line AB, with AC = 1/2 AB. Find the position vector of C. **(2)**

(d) The point D has position vector $-18\mathbf{i} + 33\mathbf{j} + 22\mathbf{k}$. Show that D lies on the line AB and find the ratio AD : AB. **(3)**

(Total for Question 21 is 11 marks)

22 Relative to a fixed origin O, the points A, B and C have position vectors OA = -i - j, OB = j + 2k and OC = 4i + 9j + pk, where p is a constant. A, B and C are collinear.

(a) Find the vectors AB and BC, giving BC in terms of p. **(3)**

(b) Use the fact that A, B and C are collinear to find the value of p. **(3)**

(c) Hence write down the ratio AB : BC. **(1)**

(Total for Question 22 is 7 marks)

23 Relative to a fixed origin O, the points A, B and C have position vectors OA = i + 6k, OB = 9i + 2j + 4k and OC = 21i + pj + k, where p is a constant. A, B and C are collinear.

(a) Find the vectors AB and BC, giving BC in terms of p. **(3)**

(b) Use the fact that A, B and C are collinear to find the value of p. **(3)**

(c) Hence write down the ratio AB : BC. **(1)**

(Total for Question 23 is 7 marks)

24 Relative to a fixed origin O, the points A and B have position vectors OA = -4i + 5j + 5k and OB = -5i - 2j - 6k.

(a) Find the vector AB and the exact length |AB|. **(4)**

(b) Find the position vector of the midpoint M of AB. **(2)**

(c) The point C lies on the line AB, with AC = 1/2 AB. Find the position vector of C. **(2)**

(d) The point D has position vector -3i + 12j + 16k. Show that D lies on the line AB and find the ratio AD : AB. **(3)**

(Total for Question 24 is 11 marks)

25 The vectors a and b are given by $a = -6i + 3j$ and $b = 6i + 2j$.

(a) Find $a + 4b$, and its magnitude to 3 significant figures. **(4)**

(b) Find the angle that $a + 4b$ makes with the positive i direction, measured anticlockwise, to 1 decimal place. **(2)**

(c) Given that $a + \lambda b$ is parallel to j, find the value of λ. **(2)**

(Total for Question 25 is 8 marks)

26 Relative to a fixed origin O, the points A, B and C have position vectors OA = 2i - j - k, OB = -3i - 2j + k and OC = -2i + 3j + 2k.

(a) Find the exact lengths of the sides |AB|, |AC| and |BC| of triangle ABC. **(3)**

(b) Find the size of angle BAC to 1 decimal place. **(3)**

(c) Find the area of triangle ABC to 3 significant figures. **(2)**

(Total for Question 26 is 8 marks)

27 The quadrilateral OABC has position vectors, relative to O, of 0, a, a + c and c respectively, where a and c are non-zero, non-parallel vectors.

(a) Show that OABC is a parallelogram. **(3)**

(b) M is the midpoint of the diagonal OB and N is the midpoint of the diagonal AC. Show that M and N are the same point. **(4)**

(c) Given that a = 4i - j and c = i + 3j, find the coordinates of the point where the diagonals of OABC intersect. **(3)**

(Total for Question 27 is 10 marks)

28 Three forces F1 = (3i + 2j) N, F2 = (-i + 5j) N and F3 = (π + qj) N act on a particle which is in equilibrium.

(a) Find the values of p and q. **(3)**

(b) Find the magnitude of F3, giving your answer in newtons to 3 significant figures. **(2)**

(c) A fourth force F4 is now applied so that the resultant of all four forces is 10i N. Find F4. **(2)**

(Total for Question 28 is 7 marks)

29 Relative to a fixed origin O, the points A, B and C have position vectors OA = i + 2j - k, OB = 4i - j + 5k and OC = (4t-1)i - 4j + 11k, where t is a constant.

(a) Find the vector AB. **(2)**

(b) Given that A, B and C are collinear, find the value of t. **(5)**

(c) Using the value of t found in part (b), show that B is the midpoint of AC. **(3)**

(Total for Question 29 is 10 marks)

30 Three forces F1 = (4i - 3j) N, F2 = (-2i + 5j) N and F3 = (π + qj) N act on a particle which is in equilibrium.

(a) Find the values of p and q. **(2)**

(b) Find the magnitude of F3, giving your answer in newtons to 3 significant figures. **(2)**

(Total for Question 30 is 4 marks)

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31 Two survey points D and E have position vectors, relative to a fixed origin O and measured in metres, OD = 3i - 2j + 5k and OE = 9i + 4j - 7k.

(a) Find the vector DE, and hence find |DE|, giving your answer in metres to 3 significant figures. **(3)**

(b) The point F lies on DE such that DF : FE = 2 : 1. Find the position vector of F. **(2)**

(Total for Question 31 is 5 marks)

32 Relative to a fixed origin O, points A and B have position vectors OA = 3i - j + 4k and OB = -i + 7j - 4k. The point X lies on the line segment AB such that AX = t x AB, where $0 \leq t \leq 1$.

(a) Find the vector AB. **(2)**

(b) Show that OX = (3-4t)i + (8t-1)j + (4-8t)k. **(2)**

(c) Given that $|OX| = \sqrt{10}$, show that $18t^2 - 13t + 2 = 0$, and hence find the possible values of t. **(7)**

(Total for Question 32 is 11 marks)

33 In triangle OAB, OA = a and OB = b. The point P lies on OA such that OP = (2/5)a, and the point Q lies on AB such that AQ = (3/4)AB.

(a) Find AB in terms of a and b. **(1)**

(b) Show that PQ = (3/20)(5b - a), fully simplified. **(4)**

(c) A point R lies on OB such that OR = (1/4)b. Determine, showing full working, whether P, Q and R are collinear. **(4)**

(Total for Question 33 is 9 marks)

Mark scheme · 1.10 Pure: Vectors

Question 1

3i + 6j cao **B1**

Answer: 3i + 6j

Question 2

5i - 4j cao **B1**

Answer: 5i - 4j

Question 3

(a) $\sqrt{3^2 + (-4)^2}$ **M1**

(a) = 5 cao **A1**

(a) Answer: |a| = 5

(b) divide a by |a| found in (a) **M1**

(b) = (3/5)i - (4/5)j oe **A1**

(b) Answer: (3/5)i - (4/5)j

(c) attempt 2b and add to a **M1**

(c) a + 2b = -i + 6j cao **A1**

(c) $\sqrt{(-1)^2 + 6^2}$ **M1**

(c) awrt 6.08 **A1**

(c) Answer: a + 2b = -i + 6j, |a + 2b| = awrt 6.08

Question 4

|a| = 13 cao **B1**

Answer: 13

Question 5

k = 4 cao **B1**

Answer: k = 4

Question 6

|b| = 10 cao **B1**

Answer: 10

Question 7

0.6i - 0.8j oe, using |6i-8j| = 10 **B1**

Answer: 0.6i - 0.8j

Question 8

AB = 5i - 12j cao **B1**

Answer: 5i - 12j

Question 9

parallel, since 4i-6j = -2(-2i+3j), a scalar multiple **B1**

Answer: Parallel

Question 10

(a) find PQ = q - p **M1**

(a) PQ = 6i - 6j **A1**

(a) r = p + (2/3)PQ **M1**

(a) r = 6i - j cao **A1**

(a) Answer: r = 6i - j

(b) RS = s - r **M1**

(b) RS = 6i + 6j **A1**

(b) find |RS| = $6\sqrt{2}$ and divide RS by |RS| **M1**

(b) unit vector = $(\sqrt{2}/2)$i + $(\sqrt{2}/2)$j oe (awrt 0.707i + 0.707j) **A1**

(b) Answer: RS = 6i + 6j; unit vector = $(\sqrt{2}/2)$i + $(\sqrt{2}/2)$j

Question 11

(a) OE - OD **M1**

(a) DE = 4i + 4j - 6k **A1**

(a) $\sqrt{4^2+4^2+(-6)^2}$ **M1**

(a) awrt 8.25 m **A1**

(a) Answer: DE = 4i+4j-6k; |DE| = awrt 8.25 m

(b) F = D + (3/4)DE (ft from (a)) **M1**

(b) F = 5i + 2j - 0.5k oe **A1**

(b) Answer: OF = 5i + 2j - 0.5k

(c) F is closer to E, since DF:FE = 3:1 means FE is only 1 part of the 4 compared to DF's 3 parts **B1**

(c) Answer: F is closer to E

Question 12

|a| = $\sqrt{9+4+36}$ = 7 **M1**

unit vector = (3/7)i - (2/7)j + (6/7)k oe **A1**

Answer: |a| = 7; unit vector = (3/7)i - (2/7)j + (6/7)k

Question 13

sets up t/2 = 15/(-5) oe from the parallel condition **M1**

t = -6 cao **A1**

Answer: t = -6

Question 14

M = (OA + OB)/2 **M1**

OM = 5i + 2j cao **A1**

Answer: OM = 5i + 2j

Question 15

OB - OA **M1**

AB = 4i - 4j + 8k cao **A1**

|AB| = $\sqrt{16+16+64}$ = $\sqrt{96}$ = $4\sqrt{6}$ cao (exact) **A1**

Answer: AB = 4i - 4j + 8k, |AB| = $4\sqrt{6}$

Question 16

add corresponding components **M1**

resultant = -4i + 7j (N) cao **A1**

magnitude = $\sqrt{16+49}$ = awrt 8.06 N **A1**

Answer: Resultant = -4i + 7j (N), magnitude awrt 8.06 N

Question 17

find PQ = OQ - OP **M1**

PQ = 8i - 8j + 8k **A1**

r = OP + (3/4)PQ **M1**

OR = 7i - 2j + 3k cao **A1**

Answer: OR = 7i - 2j + 3k

Question 18

(a) AB = b - a **B1**

(a) AP = (1/3) AB and OP = OA + AP **M1**

(a) OP = (2/3)a + (1/3)b **A1**

(a) Answer: AB = b - a, OP = (2/3)a + (1/3)b

(b) OQ = (4/5) OP **M1**

(b) (8/15)a + (4/15)b **A1**

(b) Answer: (8/15)a + (4/15)b

(c) AQ = AO + OQ = -a + OQ **M1**

(c) -(7/15)a + (4/15)b **A1**

(c) Answer: -(7/15)a + (4/15)b

Question 19

(a) AB = OB - OA **M1**

(a) AB = 4i - 3j + 3k **A1**

(a) uses Pythagoras in three dimensions **M1**

(a) $|AB| = \sqrt{34}$ **A1**

(a) Answer: AB = 4i - 3j + 3k, $|AB| = \sqrt{34}$

(b) (1/2)(OA + OB) **M1**

(b) -i + (1/2)j + (5/2)k **A1**

(b) Answer: -i + (1/2)j + (5/2)k

(c) OC = OA + 2 AB **M1**

(c) 5i - 4j + 7k **A1**

(c) Answer: 5i - 4j + 7k

(d) finds AD = OD - OA **M1**

(d) AD = 12i - 9j + 9k = 3 AB, a multiple of AB, so D lies on the line AB **A1**

(d) AD : AB = 3 : 1 **B1**

(d) Answer: AD = 3 AB, so AD : AB = 3 : 1

Question 20

(a) adds the i components and the j components: a + 3b **M1**

(a) 10i + 4j **A1**

(a) uses $|v| = \sqrt{x^2 + y^2}$ **M1**

(a) 10.8 **A1**

(a) Answer: 10i + 4j, magnitude 10.8

(b) tan θ = y/x with a quadrant check **M1**

(b) 21.8 degrees **A1**

(b) Answer: 21.8 degrees

(c) sets the i component of a + λ b to zero **M1**

(c) 7 + λ(1) = 0, so λ = -7 **A1**

(c) Answer: λ = -7

Question 21

(a) AB = OB - OA **M1**

(a) AB = 7i - 13j - 7k **A1**

(a) uses Pythagoras in three dimensions **M1**

(a) $|AB| = \sqrt{267}$ **A1**

(a) Answer: AB = 7i - 13j - 7k, $|AB| = \sqrt{267}$

(b) (1/2)(OA + OB) **M1**

(b) -(1/2)i + (1/2)j + (9/2)k **A1**

(b) Answer: -(1/2)i + (1/2)j + (9/2)k

(c) OC = OA + 1/2 AB **M1**

(c) -(1/2)i + (1/2)j + (9/2)k **A1**

(c) Answer: -(1/2)i + (1/2)j + (9/2)k

(d) finds AD = OD - OA **M1**

(d) AD = -14i + 26j + 14k = -2 AB, a multiple of AB, so D lies on the line AB **A1**

(d) AD : AB = 2 : 1 (D is on the opposite side of A from B) **B1**

(d) Answer: AD = -2 AB, so AD : AB = 2 : 1

Question 22

(a) uses AB = OB - OA and BC = OC - OB **M1**

(a) AB = i + 2j + 2k **A1**

(a) BC = 4i + 8j + (p - 2)k **A1**

(a) Answer: AB = i + 2j + 2k, BC = 4i + 8j + (p - 2)k

(b) BC = λ AB, so compares the known components to find λ **M1**

(b) λ = 4 **A1**

(b) p = 10 **A1**

(b) Answer: p = 10

(c) AB : BC = 1 : 4 **B1**

(c) Answer: AB : BC = 1 : 4

Question 23

(a) uses AB = OB - OA and BC = OC - OB **M1**

(a) AB = 8i + 2j - 2k **A1**

(a) BC = 12i + (p - 2)j - 3k **A1**

(a) Answer: AB = 8i + 2j - 2k, BC = 12i + (p - 2)j - 3k

(b) BC = λ AB, so compares the known components to find λ **M1**

(b) λ = 3/2 **A1**

(b) p = 5 **A1**

(b) Answer: p = 5

(c) AB : BC = 1 : 3/2 **B1**

(c) Answer: AB : BC = 1 : 3/2

Question 24

(a) AB = OB - OA **M1**

(a) AB = -i - 7j - 11k **A1**

(a) uses Pythagoras in three dimensions **M1**

(a) $|AB| = 3\sqrt{19}$ **A1**

(a) Answer: AB = -i - 7j - 11k, $|AB| = 3\sqrt{19}$

(b) (1/2)(OA + OB) **M1**

(b) -(9/2)i + (3/2)j - (1/2)k **A1**

(b) Answer: -(9/2)i + (3/2)j - (1/2)k

(c) OC = OA + 1/2 AB **M1**

(c) -(9/2)i + (3/2)j - (1/2)k **A1**

(c) Answer: -(9/2)i + (3/2)j - (1/2)k

(d) finds AD = OD - OA **M1**

(d) AD = i + 7j + 11k = -1 AB, a multiple of AB, so D lies on the line AB **A1**

(d) AD : AB = 1 : 1 (D is on the opposite side of A from B) **B1**

(d) Answer: AD = -1 AB, so AD : AB = 1 : 1

Question 25

(a) adds the i components and the j components: a + 4b **M1**

(a) 18i + 11j **A1**

(a) uses $|v| = \sqrt{x^2 + y^2}$ **M1**

(a) 21.1 **A1**

(a) Answer: 18i + 11j, magnitude 21.1

(b) tan θ = y/x with a quadrant check **M1**

(b) 31.4 degrees **A1**

(b) Answer: 31.4 degrees

(c) sets the i component of a + λ b to zero **M1**

(c) -6 + λ(6) = 0, so λ = 1 **A1**

(c) Answer: λ = 1

Question 26

(a) finds AB, AC and BC by subtracting position vectors **M1**

(a) $|AB| = \sqrt{30}$ **A1**

(a) $|AC| = \sqrt{41}$, $|BC| = 3\sqrt{3}$ **A1**

(a) Answer: $|AB| = \sqrt{30}$, $|AC| = \sqrt{41}$, $|BC| = 3\sqrt{3}$

(b) cosine rule: $\cos A = (AB^2 + AC^2 - BC^2)/(2\,|AB||AC|)$ **M1**

(b) cos A = (30 + 41 - 27)/(2 x 5.477 x 6.403) = 0.6273 **A1**

(b) angle BAC = 51.1 degrees **A1**

(b) Answer: 51.1 degrees

(c) (1/2)|AB||AC| sin A **M1**

(c) 13.7 **A1**

(c) Answer: 13.7

Question 27

(a) find AB = OB - OA **M1**

(a) AB = c, so AB = OC **A1**

(a) cso: one pair of opposite sides (AB, OC) equal and parallel, so OABC is a parallelogram **A1**

(a) Answer: AB = OC = c, so OABC is a parallelogram

(b) OM = (1/2)(a+c) **M1**

(b) correct OM **A1**

(b) ON = OA + (1/2)AC = a + (1/2)(c-a) **M1**

(b) cso: ON simplifies to (1/2)(a+c) = OM, so M and N coincide **A1**

(b) Answer: OM = ON = (1/2)(a+c), so M and N are the same point

(c) substitute a, c into (1/2)(a+c) **M1**

(c) (1/2)(5i+2j) **M1**

(c) coordinates (2.5, 1) cao **A1**

(c) Answer: (2.5, 1)

Question 28

(a) set sum of i- and j-components equal to zero (equilibrium) **M1**

(a) p = -2 **A1**

(a) q = -7 **A1**

(a) Answer: p = -2, q = -7

(b) $\sqrt{p^2+q^2}$ using values from (a) **M1**

(b) awrt 7.28 N **A1**

(b) Answer: awrt 7.28 N

(c) recognise F1+F2+F3 = 0 from part (a), so F4 alone equals the new resultant **M1**

(c) F4 = 10i N (+0j) cao ft **A1**

(c) Answer: F4 = 10i N

Question 29

(a) OB - OA **M1**

(a) = 3i - 3j + 6k cao **A1**

(a) Answer: AB = 3i - 3j + 6k

(b) find AC = OC - OA **M1**

(b) AC = (4t-2)i - 6j + 12k **A1**

(b) use j- or k-component ratio to find AC = m x AB with m = 2 **M1**

(b) solve i-component: 4t - 2 = 3m **dM1**

(b) t = 2 cao **A1**

(b) Answer: t = 2

(c) find BC = OC - OB using t = 2 **M1**

(c) BC = 3i - 3j + 6k **A1**

(c) cso: BC = AB, so B is the midpoint of AC **A1**

(c) Answer: BC = AB, so B is the midpoint of AC

Question 30

(a) sets the sum of i- and j-components equal to zero (equilibrium) **M1**

(a) p = -2 and q = -2 **A1**

(a) Answer: p = -2, q = -2

(b) $\sqrt{p^2+q^2}$ using values from (a) **M1**

(b) awrt 2.83 N **A1**

(b) Answer: awrt 2.83 N

Question 31

(a) OE - OD **M1**

(a) DE = 6i + 6j - 12k **A1**

(a) $|DE| = \sqrt{36+36+144}$ = awrt 14.7 m **A1**

(a) Answer: DE = 6i + 6j - 12k, |DE| = awrt 14.7 m

(b) F = OD + (2/3)DE (ft from (a)) **M1**

(b) OF = 7i + 2j - 3k oe **A1**

(b) Answer: OF = 7i + 2j - 3k

Question 32

(a) OB - OA **M1**

(a) = -4i + 8j - 8k cao **A1**

(a) Answer: AB = -4i + 8j - 8k

(b) OX = OA + t x AB **M1**

(b) cso: correctly simplified to given expression **A1**

(b) Answer: OX = (3-4t)i + (8t-1)j + (4-8t)k

(c) form $|OX|^2 = (3-4t)^2 + (8t-1)^2 + (4-8t)^2$ **M1**

(c) = $144t^2$ - 104t + 26 (unsimplified sum correct) **A1**

(c) set equal to 10 and rearrange **M1**

(c) cso: $18t^2$ - 13t + 2 = 0 shown **A1**

(c) solve the quadratic (factorise or formula) **dM1**

(c) t = 1/2 or t = 2/9 cao (both values) **A1**

(c) ft: both values lie in $0 \leq t \leq 1$, so both give valid positions of X **B1**

(c) Answer: t = 1/2 or t = 2/9

Question 33

(a) AB = b - a oe **B1**

(a) Answer: AB = b - a

(b) find OQ = a + (3/4)(b-a) **M1**

(b) OQ = (1/4)a + (3/4)b **A1**

(b) PQ = OQ - OP **M1**

(b) cso: PQ = (3/20)(5b - a) fully simplified as printed **A1**

(b) Answer: PQ = (3/20)(5b - a)

(c) find PR = OR - OP **M1**

(c) PR = (1/4)b - (2/5)a **A1**

(c) attempt to compare PR with PQ as a scalar multiple (compare coefficients of a and b) **M1**

(c) cso: coefficient ratios 1/3 (for b) and 8/3 (for a) are unequal, so PR is not a scalar multiple of PQ, hence P, Q, R are not collinear **A1**

(c) Answer: P, Q and R are not collinear