A-LEVEL MATHS (EDEXCEL 9MA0) · PURE YEAR 1 · CHAPTER 11: VECTORS · A* EXAM PRACTICE

Hints online, answers free with an account:
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Vectors: A* questions

84 marks

Date

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X A* exam questions

A to A*

Extended Edexcel-style questions. Show every step. The hints are at the end of the sheet. Use one at a time.

X1 Relative to a fixed origin O, the points A, B and C have position vectors $\overrightarrow{OA} = 3\mathbf{i} - \mathbf{j}$, $\overrightarrow{OB} = -\mathbf{i} + \mathbf{j}$ and $\overrightarrow{OC} = 7\mathbf{i} + 7\mathbf{j}$.

(a) Find $\overrightarrow{AB}$, $\overrightarrow{AC}$ and $\overrightarrow{BC}$, and hence show that angle $BAC = 90^\circ$. [4 marks]

(b) The points A, B and C lie on a circle. Find an equation of the circle. [3 marks]

Answer equation: ...

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(c) The point D is such that $ABDC$ is a rectangle. Find $\overrightarrow{OD}$ and show that D also lies on the circle. [3 marks]

Answer $\overrightarrow{OD} = \ldots$

(d) The point P lies on the circle. Find the greatest possible area of triangle PBC, and the two possible position vectors of P that give it. [5 marks]

Answer greatest area $= \ldots$, $\overrightarrow{OP} = \ldots$

Total for X1: 15 marks

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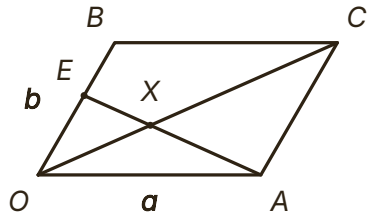
X2 $OACB$ is a parallelogram with $\overrightarrow{OA} = \mathbf{a}$ and $\overrightarrow{OB} = \mathbf{b}$. The point E lies on OB with $\overrightarrow{OE} = k\mathbf{b}$, where $0 < k < 1$. The line AE meets the diagonal OC at the point X, where $OX : XC = 2 : 5$. The diagram is not drawn to scale. Find the value of k, and hence find the ratios $OE : EB$ and $AX : XE$. [9 marks]



Answer $k = \ldots$, $OE : EB = \ldots$, $AX : XE = \ldots$

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X3 The vectors $\mathbf{a} = p\mathbf{i} + q\mathbf{j}$ and $\mathbf{b} = r\mathbf{i} + s\mathbf{j}$ are both non-zero.

(a) Prove that if $|\mathbf{a} + \mathbf{b}| = |\mathbf{a} - \mathbf{b}|$, then $\mathbf{a}$ and $\mathbf{b}$ are perpendicular. [6 marks]

(b) Given that $\mathbf{a} = (k+2)\mathbf{i} + 3\mathbf{j}$ and $\mathbf{b} = (k-1)\mathbf{i} + (k+1)\mathbf{j}$, where k is a constant, find the exact values of k for which $|\mathbf{a} + \mathbf{b}| = |\mathbf{a} - \mathbf{b}|$. [4 marks]

Answer $k = \ldots$

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(c) For the vectors in part (b), show that there is no value of k for which $\mathbf{a}$ is parallel to $\mathbf{b}$. [3 marks]

Total for X3: 13 marks

X4 A point P moves so that its position vector relative to a fixed origin O is $\overrightarrow{OP} = (2 + \cos\theta)\mathbf{i} + (-1 + \sin\theta)\mathbf{j}$, where $0 \leq \theta < 360°$.

(a) Show that P always lies on a circle, and state its centre and radius. [3 marks]

Answer centre ... , radius ...

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(b) Find the exact greatest and least values of $|\overrightarrow{OP}|$. [4 marks]

Answer greatest $= \ldots$, least $= \ldots$

(c) Find the value of θ at which $|\overrightarrow{OP}|$ is greatest. Give your answer to one decimal place. [3 marks]

Answer $\theta = \ldots$

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(d) Show that $|\overrightarrow{OP}|^2 = 6 + 4\cos\theta - 2\sin\theta$. Hence find the exact greatest value of $4\cos\theta - 2\sin\theta$. [3 marks]

Answer greatest value $= \ldots$

Total for X4: 13 marks

X5 OAB is a triangle with $\overrightarrow{OA} = \mathbf{a}$ and $\overrightarrow{OB} = \mathbf{b}$. The point M is the midpoint of AB.

(a) The point L lies on OA with $OL : LA = 1 : 2$, and the point N is such that $\overrightarrow{ON} = -\mathbf{b}$. Prove that L, M and N lie on a straight line, and find the ratio $LM : MN$. [5 marks]

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(b) Now L lies on OA with $OL : LA = 1 : k$, where $k > 0$ and $k \neq 1$. The line through L and M meets the line through O and B at the point N. Show that $\overrightarrow{ON} = \dfrac{1}{1-k}\mathbf{b}$. [4 marks]

(c) Explain what happens when $k = 1$. [2 marks]

Total for X5: 11 marks

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X6 $OABC$ is a rhombus. Relative to O, the point A has position vector $3\mathbf{i} + 4\mathbf{j}$, and the diagonal $\overrightarrow{OB}$ is parallel to $7\mathbf{i} + \mathbf{j}$. Find the position vector of C, and show that $OABC$ is a square. [10 marks]

Answer $\overrightarrow{OC} = \ldots$

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X7 $OACB$ is a parallelogram with $\overrightarrow{OA} = \mathbf{a}$, $\overrightarrow{OB} = \mathbf{b}$ and $\overrightarrow{OC} = \mathbf{a} + \mathbf{b}$. You are given that $|\mathbf{a}| = 3$, $|\mathbf{b}| = 5$ and angle $AOB = 60°$.

(a) Show that $|\mathbf{a} + \mathbf{b}| = 7$, and find the exact value of $|\mathbf{b} - \mathbf{a}|$. [4 marks]

Answer $|\mathbf{b} - \mathbf{a}| = \ldots$

(b) Show that $\cos(\text{angle } AOC) = \dfrac{11}{14}$. [2 marks]

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(c) The point F lies on OC and AF is perpendicular to OC. [4 marks]
Show that $\overrightarrow{OF} = \frac{33}{98}(\mathbf{a} + \mathbf{b})$, and find the exact length AF.

Answer $AF = \ldots$

(d) Hence find the exact area of the parallelogram $OACB$, and the exact distance between the parallel lines OA and BC. [3 marks]

Answer area $= \ldots$, distance $= \ldots$

Total for X7: 13 marks

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F How did it go?

Colour one circle on each line.

	Not yet	Nearly	Yes
I can find a ratio in a shape by writing one position vector in two ways and comparing coefficients of non-parallel vectors.	○	○	○
I can prove that points are collinear, or that lines are parallel or perpendicular, using vectors.	○	○	○
I can solve problems where the components of a vector depend on a constant.	○	○	○
I can link vectors to circles, Pythagoras and trigonometry to find greatest and least values.	○	○	○

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Hints

Use one hint at a time. Cover the ones below it with a sheet of paper.

X1

Hint 1 To show a right angle without a protractor, compare the squared lengths of the three sides.

Hint 2 An angle of 90° at A on a circle means the side opposite it is a diameter. For D, walk from B along the same vector as from A to C.

Hint 3 With BC fixed as the base, the area depends only on the height of P above BC. The height is greatest when P is at the end of the radius perpendicular to BC.

X2

Hint 1 Write $\overrightarrow{OX}$ in two ways: once using the ratio along OC, and once as a point on the line AE, $\mathbf{a} + \mu\overrightarrow{AE}$.

Hint 2 $\overrightarrow{AE} = k\mathbf{b} - \mathbf{a}$. Collect the $\mathbf{a}$ terms and the $\mathbf{b}$ terms of your second expression.

Hint 3 Because $\mathbf{a}$ and $\mathbf{b}$ are not parallel, the coefficients of $\mathbf{a}$ must agree and so must the coefficients of $\mathbf{b}$. This gives two equations in μ and k.

X3

Hint 1 Square both magnitudes. Many terms cancel when you set them equal.

Hint 2 $pr + qs = 0$ says the gradients multiply to -1, as long as no component is zero. Treat the case of a zero component on its own.

Hint 3 For part (c), two vectors are parallel when one is a multiple of the other, so the ratios of their components are equal. Show the resulting quadratic has no real roots.

X4

Hint 1 Write x and y in terms of θ, then find $(x-2)^2 + (y+1)^2$.

Hint 2 The point of a circle furthest from an outside point lies on the line through that point and the centre.

Hint 3 For part (d), the greatest value of $6 + 4\cos\theta - 2\sin\theta$ is the square of your greatest $|\overrightarrow{OP}|$.

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X5

Hint 1 Find $\overrightarrow{LM}$ and $\overrightarrow{MN}$ in terms of $\mathbf{a}$ and $\mathbf{b}$. Collinear means one is a multiple of the other and they share a point.

Hint 2 For part (b), any point on the line through L and M is $\overrightarrow{OL} + s\overrightarrow{LM}$. Points on the line through O and B are multiples of $\mathbf{b}$ alone.

Hint 3 Set the coefficient of $\mathbf{a}$ to 0 to find s, then read off the coefficient of $\mathbf{b}$.

X6

Hint 1 In a rhombus all four sides are equal, so $|\overrightarrow{OC}| = |\overrightarrow{OA}|$.

Hint 2 The diagonal is $\overrightarrow{OB} = \overrightarrow{OA} + \overrightarrow{OC}$. Parallel to $7\mathbf{i} + \mathbf{j}$ means its $\mathbf{i}$ component is 7 times its $\mathbf{j}$ component.

Hint 3 You will get two answers. Check what the shape would look like for each one. For the square, test the angle at O with Pythagoras.

X7

Hint 1 $\overrightarrow{AC} = \overrightarrow{OB} = \mathbf{b}$, so triangle OAC has sides 3 and 5 meeting at A. The angle at A is not $60°$: angles next to each other in a parallelogram add up to $180°$.

Hint 2 F is the foot of the perpendicular from A, so triangle OAF has a right angle at F and $OF = OA\cos(\text{angle } AOC)$.

Hint 3 $\overrightarrow{OF}$ is the fraction $\dfrac{OF}{OC}$ of $\overrightarrow{OC}$. For the area, AF is the height of triangle OAC on the base OC.

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