Name	Date started	Target end date

GCE A LEVEL — APPLIED MATHEMATICS B QUESTION PACK

0981-01 (Legacy M2) · New spec Unit 4 Topic 5 · A2 unit, 15% of A-level, 80 marks, 1h 45min paper

REVISE
.wales

MATHEMATICS — APPLIED B · KINEMATICS - VECTORS (POSITION & CLOSEST APPROACH)

Kinematics - Position Vectors and Closest Approach

Every position-vector and closest-approach question (constant-velocity 2D motion) from the legacy WJEC M2 papers (2011-2016)

LEGACY 2008 SPECIFICATION

Estimated time for entire question pack: ~0 hours 56 minutes

*Derived from the legacy M2 paper's pace of **~1.25 min/mark** (45 marks over 5 questions).*

*You are advised to **not** attempt to complete all of this in one sitting.*

ABOUT THIS QUESTION PACK

This is a **comprehensive practice question pack**, not a single mock paper. It contains questions from the legacy WJEC M2 papers (2008 modular spec) that maps onto new-spec A2 Unit 4 Topic 5 (2.4.5).

Questions are ordered chronologically.

INSTRUCTIONS

Use black ink or black ball-point pen. Show all working — method marks are awarded for clear setup.

A calculator is allowed (except where specified by individual questions). The WJEC Formula Booklet and statistical tables may be referred to. Take $g = 9.8\,\mathrm{ms}^{-2}$ for mechanics.

For Examiner's use only

Q	Source	Max	Mark
1	Jun 11 Q7	10	
2	Jun 12 Q8	10	
3	Jun 14 Q4	10	
4	Jun 15 Q1	6	
5	Jun 16 Q3	9	
	Total	45	

Kinematics - Position Vectors and Closest Approach — what the new spec asks

WJEC GCE A Level Mathematics (from 2017) · Unit 4: Applied Mathematics B · Topic 2.4.5.

Position vectors 2.4.5

- Particle at $\mathbf{r}(t) = \mathbf{r}_0 + t\mathbf{v}$ for constant-velocity motion.
- Displacement between two particles: $\overrightarrow{AB} = \mathbf{r}_B - \mathbf{r}_A$.
- Distance is $|\overrightarrow{AB}|$; closest when $\frac{d}{dt}|\overrightarrow{AB}|^2 = 0$.

Scalar (dot) product 2.4.5

- $\mathbf{a} \cdot \mathbf{b} = a_1 b_1 + a_2 b_2 + a_3 b_3$.
- Perpendicular vectors: $\mathbf{a} \cdot \mathbf{b} = 0$.
- Angle between: $\cos\theta = \dfrac{\mathbf{a} \cdot \mathbf{b}}{|\mathbf{a}||\mathbf{b}|}$.

Kinematics - Vectors (Position & Closest Approach) in one page

Quick-reference notes — revisit before each section. Don't use during questions.

Constant velocity model

$\mathbf{r}(t) = \mathbf{r}_0 + t\mathbf{v}$.

Linear in t — straight-line motion in 2D / 3D.

Speed $= |\mathbf{v}|$.

Distance between particles

$\overrightarrow{AB}(t) = \mathbf{r}_B - \mathbf{r}_A$.

$AB^2 = |\overrightarrow{AB}|^2$ is quadratic in t — minimise by differentiating or completing the square.

Closest approach

$\frac{d}{dt}(AB^2) = 0 \Rightarrow$ time of closest approach.

Substitute back for minimum distance.

Quicker: $\overrightarrow{AB} \cdot \frac{d\overrightarrow{AB}}{dt} = 0$ at closest point.

Perpendicular vectors

$\mathbf{a} \cdot \mathbf{b} = 0$.

For 3D: $a_1b_1 + a_2b_2 + a_3b_3 = 0$.

Solve the trig / algebraic equation that pops out.

Speed and momentum

Speed $|\mathbf{v}| = \sqrt{v_1^2 + v_2^2 + v_3^2}$.

Momentum vector: $\mathbf{p} = m\mathbf{v}$; magnitude $|\mathbf{p}| = m|\mathbf{v}|$.

Intercept (boat meeting ship)

Set $\mathbf{r}_S(t) = \mathbf{r}_B(t)$ at intercept; solve for time + unknown velocity.

Sometimes given target time; sometimes the unknown is direction.

SECTION T5

Kinematics - Position Vectors and Closest Approach

Questions 1–5 · 45 marks

7. At time t, the position vectors relative to a fixed origin O, of two particles A and B are given by $\mathbf{OA} = 2\mathbf{i} + 3\mathbf{j} + \mathbf{k} + t(2\mathbf{i} - 6\mathbf{j} + 9\mathbf{k})$ and $\mathbf{OB} = 5\mathbf{i} - 8\mathbf{j} + 10\mathbf{k} + t(3\mathbf{i} - 6\mathbf{j} + 7\mathbf{k})$.

(a) Find the speed of particle A. [3]

(b) Show that the distance AB at time t is given by $AB^2 = 5t^2 - 30t + 211$. Determine the time at which the particles A and B are closest together. [7]

8. A ship S is moving in a straight line with constant velocity. At time $t = 0$, its position vector relative to a fixed origin O is $(8\mathbf{i} + 7\mathbf{j})$. At time $t = 3$, its position vector is $(14\mathbf{i} - 5\mathbf{j})$.

(a) Show that the velocity of S is $(2\mathbf{i} - 4\mathbf{j})$. [2]

(b) Find an expression, in terms of t, for the position vector of S at time t. [2]

At time $t = 10$, a boat B leaves O and travels with constant velocity $x\mathbf{i} + y\mathbf{j}$, intercepting S at time $t = 50$.

(c) Calculate the value of x and the value of y. [6]

4. At time $t = 0$, an aeroplane A has position vector $(3\mathbf{i} + 5\mathbf{j} + 20\mathbf{k})$ m and is flying with constant velocity $(-\mathbf{i} + 2\mathbf{j} + \mathbf{k})$ ms^{-1}.
At time $t = 0$, another aeroplane B has position vector $(-2\mathbf{i} + x\mathbf{j} + 15\mathbf{k})$ m, and is flying with constant velocity $(3\mathbf{i} - 4\mathbf{j} + 2\mathbf{k})$ ms^{-1}.

(a) Find expressions for the position vector of A and the position vector of B at time t s. [3]

(b) Determine an expression for AB^2, where AB is the distance between A and B at time t s. [4]

(c) Given that the shortest distance between A and B occurs at $t = 5$, calculate the value of x. [3]

1. The vectors $\mathbf{x}$ and $\mathbf{y}$ are given by

$$\mathbf{x} = \sin\theta\,\mathbf{i} + 2\cos2\theta\,\mathbf{j},$$
$$\mathbf{y} = 2\mathbf{i} - \mathbf{j}.$$

Find the values of θ between 0 and 2π such that $\mathbf{x}$ is perpendicular to $\mathbf{y}$. [6]

3. At time $t = 0$ s, the position vector of an object A is $\mathbf{i}$ m and the position vector of another object B is $3\mathbf{i}$ m. The constant velocity vector of A is $2\mathbf{i} + 5\mathbf{j} - 4\mathbf{k}\,\mathrm{ms}^{-1}$ and the constant velocity vector of B is $\mathbf{i} + 3\mathbf{j} - 5\mathbf{k}\,\mathrm{ms}^{-1}$. Determine the value of t when A and B are closest together and find the least distance between A and B. [9]

END OF KINEMATICS - VECTORS (POSITION & CLOSEST APPROACH) PACK

Source: WJEC M2 (2008 modular spec) · 2011–2017
Curated for WJEC Maths 2017 spec A2 Unit 4 — Topic 5 (2.4.5)