Pearson Edexcel

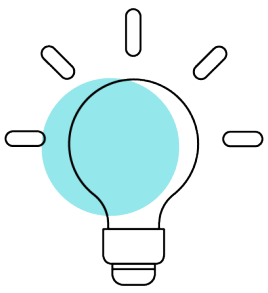
Topic Test
Summer 2022

Pearson Edexcel GCE Mathematics (9MA0)

Paper 3 – Mechanics

Topic 1: Kinematics – Constant Acceleration

Contents



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General guidance to Topic Tests

Context

- Topic Tests have come from past papers both published (those materials available publicly) and unpublished (those currently under padlock to our centres) presented in a different format to allow teachers to adapt them for use with candidates.

Purpose

- The purpose of this resource is to provide qualification-specific sets/groups of questions covering the knowledge, skills and understanding relevant to this Pearson qualification.
- This document should be used in conjunction with the advance information for the subject as well as general marking guidance for the qualification (available in published mark schemes).

Revise Revision Guide content coverage

The questions in this topic test have been taken from past papers, and have been selected as they cover the topic(s) most closely aligned to the A level advance information for summer 2022:

- Topic 1: Kinematics - Constant acceleration and Quantities and units in mechanics
  - Constant acceleration in 2-D

The focus of content in this topic test can be found in the Revise Pearson Edexcel A level Mathematics Revision Guide. Free access to this Revise Guide is available for front of class use, to support your students' revision.

Contents	Revise Guide page reference	Level
Pure Mathematics	1-111	A level
Statistics	112-147	A level
Mechanics	148-181	A level

Content on other pages may also be useful, including for synoptic questions which bring together learning from across the specification.

Questions

Question T1_Q1

8. [*In this question* **i** *and* **j** *are horizontal unit vectors due east and due north respectively and position vectors are given relative to the fixed point O.*]

A particle P moves with constant acceleration.
At time $t = 0$, the particle is at O and is moving with velocity $(2\mathbf{i} - 3\mathbf{j})\,\text{m s}^{-1}$
At time $t = 2$ seconds, P is at the point A with position vector $(7\mathbf{i} - 10\mathbf{j})\,\text{m}$.

(a) Show that the magnitude of the acceleration of P is $2.5\,\text{m s}^{-2}$

(4)

At the instant when P leaves the point A, the acceleration of P changes so that P now moves with constant acceleration $(4\mathbf{i} + 8.8\mathbf{j})\,\text{m s}^{-2}$

At the instant when P reaches the point B, the direction of motion of P is north east.

(b) Find the time it takes for P to travel from A to B.

(4)

Question 8 continued

Question 8 continued

Question 8 continued

Question T1_Q2

2. A particle, P, moves with constant acceleration $(2\mathbf{i} - 3\mathbf{j})\,\text{m s}^{-2}$

At time $t = 0$, the particle is at the point A and is moving with velocity $(-\mathbf{i} + 4\mathbf{j})\,\text{m s}^{-1}$

At time $t = T$ seconds, P is moving in the direction of vector $(3\mathbf{i} - 4\mathbf{j})$

(a) Find the value of T.

(4)

At time $t = 4$ seconds, P is at the point B.

(b) Find the distance AB.

(4)

Question 2 continued

Question T1_Q3

2. A particle P moves with acceleration $(4\mathbf{i} - 5\mathbf{j})\,\text{m s}^{-2}$

At time $t = 0$, P is moving with velocity $(-2\mathbf{i} + 2\mathbf{j})\,\text{m s}^{-1}$

(a) Find the velocity of P at time $t = 2$ seconds.

(2)

At time $t = 0$, P passes through the origin O.

At time $t = T$ seconds, where $T > 0$, the particle P passes through the point A.

The position vector of A is $(\lambda\mathbf{i} - 4.5\mathbf{j})$m relative to O, where λ is a constant.

(b) Find the value of T.

(4)

(c) Hence find the value of λ

(2)

Question 2 continued

Question T1_Q4

1. A particle P moves with constant acceleration $(2\mathbf{i} - 3\mathbf{j})\,\text{m s}^{-2}$

At time $t = 0$, P is moving with velocity $4\mathbf{i}\,\text{m s}^{-1}$

(a) Find the velocity of P at time $t = 2$ seconds.

(2)

At time $t = 0$, the position vector of P relative to a fixed origin O is $(\mathbf{i} + \mathbf{j})\,\text{m}$.

(b) Find the position vector of P relative to O at time $t = 3$ seconds.

(2)

Question 1 continued

Mark Scheme

Question T1_Q1

Question	Scheme	Marks	AOs
8(a)	Use of $\mathbf{r}=\mathbf{u}t+\frac{1}{2}\mathbf{a}t^2$: $(7\mathbf{i}-10\mathbf{j})=2(2\mathbf{i}-3\mathbf{j})+\frac{1}{2}\mathbf{a}2^2$	M1	3.1b
	$\mathbf{a}=(1.5\mathbf{i}-2\mathbf{j})$	A1	1.1b
	$\lvert\mathbf{a}\rvert=\sqrt{1.5^2+(-2)^2}$	M1	1.1b
	$= 2.5\ \text{m s}^{-2}$ * GIVEN ANSWER	A1*	2.1
		(4)	
(b)	Use of $\mathbf{v}=\mathbf{u}+\mathbf{a}t=(2\mathbf{i}-3\mathbf{j})+2(1.5\mathbf{i}-2\mathbf{j})$	M1	3.1b
	$=(5\mathbf{i}-7\mathbf{j})$	A1	1.1b
	$\mathbf{v}=(5\mathbf{i}-7\mathbf{j})+t(4\mathbf{i}+8.8\mathbf{j})=(5+4t)\mathbf{i}+(8.8t-7)\mathbf{j}$ and $(5+4t)=(8.8t-7)$	M1	3.1b
	$t=2.5$ (s)	A1	1.1b
		(4)	
			(8 marks)

Notes: Allow column vectors throughout

(a)

No credit for individual component calculations

M1: Using a complete method to obtain the acceleration. N.B. Equation, in a only, could be obtained by two integrations

ALTERNATIVE

M1: Use velocity at half-time ($t=1$) = Average velocity over time period

So at $t=1$, $\mathbf{v}=\frac{1}{2}(7\mathbf{i}-10\mathbf{j})$ so $\mathbf{a}=\frac{1}{2}(7\mathbf{i}-10\mathbf{j})-(2\mathbf{i}-3\mathbf{j})$

N.B. could see $(7\mathbf{i}-10\mathbf{j})=(4\mathbf{i}-6\mathbf{j})+2\mathbf{a}$ as first line of working

A1: Correct a vector

M1: Attempt to find magnitude of their a using form $\sqrt{a^2+b^2}$

A1*: Correct GIVEN ANSWER obtained correctly

(b)

M1: Using a complete method to obtain the velocity at A e.g.by use of $\mathbf{v}=\mathbf{u}+\mathbf{a}t$ with $t=2$ and $\mathbf{u}=2\mathbf{i}-3\mathbf{j}$ and their a

OR: by use of $\mathbf{s}=\mathbf{v}t-\frac{1}{2}\mathbf{a}t^2$

OR: by integrating their a, with addition of $\mathbf{C}=2\mathbf{i}-3\mathbf{j}$, and putting $t=2$

A1: correct vector

M1: Complete method to find equation in t only

e.g. by using $\mathbf{v} = \mathbf{u} + \mathbf{a}t$, with their **u** and equating **i** and **j** components

OR: by integrating $(4\mathbf{i} + 8.8\mathbf{j})$, with addition of a constant, and equating **i** and **j** components.

N.B. Must be equating **i** and **j** components of a velocity vector and must be their velocity at A, to give an equation in t only for this M mark

A1: 2.5 (s)

Question T1_Q2

Question	Scheme	Marks	AO
2(a)	$(\mathbf{v}=)\mathbf{C}+(2\mathbf{i}-3\mathbf{j})t$	M1	3.1a
	$(\mathbf{v}=)(-\mathbf{i}+4\mathbf{j})+(2\mathbf{i}-3\mathbf{j})t$	A1	1.1b
	$\frac{4-3T}{-1+2T}=\frac{-4}{3}$ oe	M1	3.1a
	$T=8$	A1	1.1b
		(4)	
(b)	$(\mathbf{s}=)\mathbf{C}t+(2\mathbf{i}-3\mathbf{j})\frac{1}{2}t^2$ (+ **D**)	M1	3.1a
	$(\mathbf{s}=)(-\mathbf{i}+4\mathbf{j})t+\frac{1}{2}(2\mathbf{i}-3\mathbf{j})t^2$ (+ **D**)	A1	1.1b
	$AB=\sqrt{12^2+8^2}$ **N.B. Beware you may see 4(2i – 3j) which leads to** $\sqrt{(8^2+12^2)}$ this is M0A0M0A0.	M1	3.1a
	$=4\sqrt{13}(=14.422051....)$ (m)	A1**cso**	1.1b
		(4)	
		(8)	

Marks		Notes
2a	M1	Use of $\mathbf{v}=\mathbf{u}+\mathbf{a}t$ **OR** integration to give an expression of the form $\mathbf{C}+(2\mathbf{i}-3\mathbf{j})t$ **, where C is a non-zero constant vector** M0 if **u** and **a** are reversed Condone use of **a** = (**2i** + 3**j**) for this M mark
	A1	Any correct unsimplified expression seen or implied
	M1	Correct use of ratios, using a velocity vector (must be using $\frac{-4}{3}$) to give equation in T only M0 if they equate $4-3T=-4$ and/or $-1+2T=3$ and therefore M0 if they then divide to produce their equation
	A1	Correct only
		N.B. (i) Can score the second M1A1 if they get T = 8, using a calculator to solve two simultaneous equations, but if answer is wrong, and no equation in T only, second M0 (ii) Can score M1A1 M1A1 if they get T = 8, using trial and error, but if they don't get T = 8, can only score max M1A1M0A0

Question T1_Q3

Question	Scheme	Marks	AOs
2(a)	Use of $\mathbf{v}=\mathbf{u}+\mathbf{a}t$ or integrate to give: $\mathbf{v}=(-2\mathbf{i}+2\mathbf{j})+2(4\mathbf{i}-5\mathbf{j})$	M1	3.1a
	$(6\mathbf{i}-8\mathbf{j})\,(\text{m s}^{-1})$	A1	1.1b
		(2)	
2(b)	Solve problem through use of $\mathbf{r}=\mathbf{u}t+\frac{1}{2}\mathbf{a}t^2$ or integration (M0 if $\mathbf{u}=\mathbf{0}$) **Or** any other complete method e.g use $\mathbf{v}=\mathbf{u}+\mathbf{a}T$ and $\mathbf{r}=\frac{(\mathbf{u}+\mathbf{v})T}{2}$:	M1	3.1a
	$-4.5\mathbf{j}=2t\mathbf{j}-\frac{1}{2}t^2 5\mathbf{j}$ (**j** terms only)	A1	1.1b
	The first two marks could be implied if they go straight to an algebraic equation.		
	Attempt to equate **j** components to give equation in T only $(-4.5=2T-\frac{5}{2}T^2)$	M1	2.1
	$T=1.8$	A1	1.1b
		(4)	
2(c)	Solve problem by substituting <u>their</u> T value (M0 if $T<0$) into the **i** component equation to give an equation in λ only: $\lambda=-2T+\frac{1}{2}T^2\times 4$	M1	3.1a
	$\lambda=2.9$ or 2.88 or $\frac{72}{25}$ oe	A1	1.1b
		(2)	

Notes: Accept column vectors throughout **(8 marks)**

2a	M1	For any complete method to give a **v** expression with correct no. of terms with $t=2$ used, so if integrating, must see the initial velocity as the constant. Allow sign errors.
	A1	Cao isw if they go on to find the speed.
2b	M1	For any complete method to give a vector expression for **j** component of displacement in t (or T) only, using $\mathbf{a}=(4\mathbf{i}-5\mathbf{j})$, so if integrating, RHS of equation must have the correct structure. Allow sign errors.
	A1	Correct **j** vector equation in t or T. Ignore **i** terms.
	M1	Must have earned 1st M mark.

Question T1_Q4

Question	Scheme	Marks	AOs
1(a)	Use of $\mathbf{v} = \mathbf{u} + \mathbf{a}t$ with $t = 2$: $\mathbf{v} = 4\mathbf{i} + 2(2\mathbf{i} - 3\mathbf{j})$ **OR integration**: $\mathbf{v} = (2\mathbf{i} - 3\mathbf{j})t + 4\mathbf{i}$, with $t = 2$	M1	3.1a
	$\mathbf{v} = 8\mathbf{i} - 6\mathbf{j}$	A1	1.1b
		(2)	
1(b)	Use of $\mathbf{r} = \mathbf{u}t + \frac{1}{2}\mathbf{a}t^2$ at $t = 3$: $(\mathbf{i} + \mathbf{j}) + \left[3 \times 4\mathbf{i} + \frac{1}{2} \times (2\mathbf{i} - 3\mathbf{j}) \times 3^2\right]$ **OR**: find $\mathbf{v}$ at $t = 3$: $4\mathbf{i} + 3(2\mathbf{i} - 3\mathbf{j}) = (10\mathbf{i} - 9\mathbf{j})$ then use $\mathbf{r} = \frac{1}{2}(\mathbf{u} + \mathbf{v})t$ $(\mathbf{i} + \mathbf{j}) + \left[\frac{1}{2}\left[4\mathbf{i} + (10\mathbf{i} - 9\mathbf{j})\right] \times 3\right]$ or $\mathbf{r} = \mathbf{v}t - \frac{1}{2}\mathbf{a}t^2$ $(\mathbf{i} + \mathbf{j}) + \left[3 \times (10\mathbf{i} - 9\mathbf{j}) - \frac{1}{2} \times (2\mathbf{i} - 3\mathbf{j}) \times 3^2\right]$ **OR integration:** $\mathbf{r} = (\mathbf{i} + \mathbf{j}) + \left[(2\mathbf{i} - 3\mathbf{j})\frac{1}{2}t^2 + 4t\mathbf{i}\right]$, with $t = 3$	M1	3.1a
	$\mathbf{r} = 22\mathbf{i} - 12.5\mathbf{j}$	A1	2.2a
		(2)	
			(4 marks)

Notes:		**Accept column vectors throughout**
1a	M1	Complete method to find **v**, using **ruva***t* or integration (M0 if **i** and/or **j** is missing)
	A1	Apply isw if they also find the speed
1b	M1	Complete method to find the p.v. but this mark can be scored if they omit **(i + j)** i.e. the M1 is for the expression in the square bracket If they integrate, the M1 is earned once the expression in the square bracket is seen with $t = 3$ (M0 if **i** and/or **j** is missing)
	A1	cao