

Name	Date started	Target end date
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GCE A LEVEL – APPLIED MATHEMATICS B QUESTION PACK

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

REVISE

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MATHEMATICS – APPLIED B · KINEMATICS - VARIABLE ACCELERATION

Kinematics - Variable Acceleration (1D, calculus)

Every 1D variable-acceleration question ($v(t)$, $a(t)$, $s(t)$ with calculus and $F = ma$ with variable forces) from the legacy WJEC M2 papers (2011-2017)

LEGACY 2008 SPECIFICATION

Estimated time for entire question pack: ~1 hours 10 minutes

Derived from the legacy M2 paper's pace of **~1.25 min/mark** (56 marks over 7 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 4 (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 $g = 9.8 \text{ ms}^{-2}$ for mechanics.

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Q	Source	Max	Mark
1	Jun 11 Q1	8	
2	Jun 12 Q1	3	
3	Jun 13 Q5	7	
4	Jun 14 Q2	10	
5	Jun 15 Q2	10	
6	Jun 16 Q1	9	
7	Jun 17 Q2	9	
Total		56	

Kinematics - Variable Acceleration (1D, calculus) – what the new spec asks

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

Variable acceleration in 1D 2.4.5

- Treat a , v , s as functions of t and use calculus to link them.
- $v = \int a \, dt$ and $s = \int v \, dt$, plus constants of integration.
- $a = \frac{dv}{dt} = v \frac{dv}{dx}$ for variable force questions.

F = ma with variable force 2.4.7

- Use $F = m \frac{dv}{dt}$ for F given in terms of t .
- Use $F = mv \frac{dv}{dx}$ for F given in terms of x .
- Sum all forces (driving, resistance, weight component) before applying $F = ma$.

Kinematics - Variable Acceleration in one page

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

v, a from displacement

$$v = \frac{ds}{dt}, a = \frac{dv}{dt} = \frac{d^2s}{dt^2}.$$

Going the other way: $s = \int v dt + C$,
 $v = \int a dt + C$.

v dv/dx trick

$$a = \frac{dv}{dt} = v \frac{dv}{dx} \text{ via chain rule.}$$

Use when F (and hence a) depends on x , not t .

Newton's 2nd law

$$\text{Variable force: } F(t) - R = m \frac{dv}{dt}.$$

Set up the diff eq carefully, then integrate.

Use initial condition $v(0)$ to fix C .

Distance vs displacement

Distance: $\int_a^b |v| dt$ – sum positive and negative phases as positives.

Displacement: $\int_a^b v dt$ – signed.

Find when v changes sign before integrating.

Resistance proportional to t

$$\text{If } R = kt: \text{ total force} = F_0 - kt = m \frac{dv}{dt}.$$

Integrate directly to get $v(t)$.

Common pitfalls

Forgetting the constant of integration.

Mixing up $|v|$ and v for total distance.

Forgetting resistive forces in F_{net} .

SECTION T4

Kinematics - Variable Acceleration (1D, calculus)

Questions 1-7 · 56 marks

1. A particle moves along the x -axis and its velocity $v \text{ ms}^{-1}$ at time $t \text{ s}$ is given by

$$v = 12 \sin 3t - 8 \cos 2t.$$

- (a) Find an expression for the acceleration of the particle at time $t \text{ s}$. [3]
- (b) Given that at time $t = 0$ the particle is at the origin O , find an expression for the displacement of the particle from O at time $t \text{ s}$. [5]

1. A particle moves in a straight line with velocity $v \text{ ms}^{-1}$ at time $t \text{ s}$, where

$$v = 4 \cos 2t.$$

Calculate the distance travelled by the particle between $t = 0$ and $t = \frac{\pi}{6}$ s.

[3]

5. A particle moves along a straight horizontal line. Its velocity $v \text{ ms}^{-1}$ at time $t \text{ s}$, is given by

$$v = 2t(t - 6).$$

- (a) Find the set of values of t for which the velocity of the particle is negative. [2]
- (b) Find the total distance travelled by the particle in the interval $0 \leq t \leq 9$. [5]

2. A particle of mass 5 kg moves under the action of a horizontal force given by $F = 30t^{-2} - 30$ N at time t s, where $t > 0$. It also experiences a constant resistance to motion of magnitude 120 N.

(a) Show that the motion of the particle satisfies the differential equation

$$\frac{dv}{dt} = 6t^{-2} - 30,$$

where $v \text{ ms}^{-1}$ is the velocity of the particle at time t s. [2]

(b) Calculate the value of t when the acceleration of the particle is 24 ms^{-2} . [2]

(c) Given that the velocity of the particle is 18 ms^{-1} when $t = \frac{1}{3}$, find an expression for v in terms of t . Hence find the values of t when $v = 10$. [6]

2. An object of mass 50 kg moves in a straight horizontal line under the action of a constant horizontal force of magnitude 1600 N acting along the line. The resistance to motion of the object is proportional to time t seconds. At time t seconds, the velocity of the object is v ms⁻¹ and at time $t = 2$, it is moving with velocity 41 ms⁻¹ and acceleration -4 ms⁻².

- (a) Show that v satisfies the differential equation

$$\frac{dv}{dt} = 32 - 18t. \quad [4]$$

- (b) Find an expression for v in terms of t and determine the times when the velocity of the object is 28 ms⁻¹. [6]

1. A particle of mass 4 kg moves along the x -axis, starting, when $t = 0$, from the point where $x = 3$. At time t s, its velocity $v \text{ ms}^{-1}$ is given by

$$v = 12t^2 - 7kt + 1,$$

where k is constant.

When $t = 2$, the displacement of the particle from the origin is 16 m.

- (a) Determine the value of k . [5]
- (b) Calculate the magnitude of the force acting on the particle when $t = 5$. [4]

2. A particle P , of mass 0.8 kg , moves along the x -axis so that its velocity at time t seconds is $v \text{ ms}^{-1}$, where $v = 4t^3 - 6t + 7$. Given that the displacement of P is 5 m from the origin when $t = 0$, find
- (a) the displacement of P from the origin when $t = 2$, [5]
- (b) the force acting on P when $t = 3$. [4]

END OF KINEMATICS - VARIABLE ACCELERATION PACK

Source: WJEC M2 (2008 modular spec) · 2011–2017

Curated for WJEC Maths 2017 spec A2 Unit 4 – Topic 4 (2.4.5)

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