Name	Date started	Target end date

GCE A LEVEL — APPLIED MATHEMATICS B QUESTION PACK

0981-01 (Legacy M2) · New spec Unit 4 Topic 9 · A2 unit, 15% of A-level, 80 marks, 1h 45min paper

REVISE
.wales

MATHEMATICS — APPLIED B · PROJECTILE MOTION

Projectile Motion (Full 2D)

Every projectile motion question from the legacy WJEC M2 papers (2011-2017). Trajectories, ranges, times of flight and projectile collisions

LEGACY 2008 SPECIFICATION

Estimated time for entire question pack: ~1 hours 49 minutes

*Derived from the legacy M2 paper's pace of **~1.25 min/mark** (87 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 9 (2.4.6).

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.

For Examiner's use only

Q	Source	Max	Mark
1	Jun 11 Q6	14	
2	Jun 12 Q6	13	
3	Jun 13 Q3	12	
4	Jun 14 Q5	13	

Q	Source	Max	Mark
5	Jun 15 Q6	13	
6	Jun 16 Q2	10	
7	Jun 17 Q4	12	
Total		**87**	

Projectile Motion (Full 2D) — what the new spec asks

WJEC GCE A Level Mathematics (from 2017) · Unit 4: Applied Mathematics B · Topic 2.4.6.

Projectile equations 2.4.6

- Horizontal: $x = (u\cos\alpha)t$ (constant velocity).
- Vertical: $y = (u\sin\alpha)t - \frac{1}{2}gt^2$ (under gravity).
- $g = 9.8\,\text{ms}^{-2}$ downward.

Range, height, time of flight 2.4.6

- Time of flight (level ground): $T = \dfrac{2u\sin\alpha}{g}$.
- Maximum height: $h = \dfrac{u^2\sin^2\alpha}{2g}$.
- Range (level ground): $R = \dfrac{u^2\sin 2\alpha}{g}$.

Crib sheet »

Projectile Motion in one page

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

Resolve initial velocity

$u_x = u\cos\alpha$, $u_y = u\sin\alpha$.

From $\tan\alpha = p/q$: $\sin\alpha = p/\sqrt{p^2+q^2}$, $\cos\alpha = q/\sqrt{p^2+q^2}$.

Standard motion equations

Horizontal: $x = u\cos\alpha\, t$.

Vertical: $y = u\sin\alpha\, t - \frac{1}{2}gt^2$.

Vertical velocity: $v_y = u\sin\alpha - gt$.

Hitting a point

For target at (X, Y): set $x = X$, $y = Y$, eliminate t.

Get a quadratic in $\tan\alpha$ to find required angle / speed.

Speed and direction on landing

Final speed: $v = \sqrt{v_x^2 + v_y^2}$.

Direction below horizontal: $\tan\theta = |v_y|/v_x$.

Time of flight & range (level)

$T = \dfrac{2u\sin\alpha}{g}$ — on level ground.

$R = \dfrac{u^2\sin 2\alpha}{g}$ — on level ground.

Don't quote these blindly when start and end heights differ.

Trajectory equation

Eliminate t: $y = x\tan\alpha - \dfrac{gx^2}{2u^2\cos^2\alpha}$.

Useful for 'does the projectile clear / miss?' questions.

SECTION T9

Projectile Motion (Full 2D)

Questions 1–7 · 87 marks

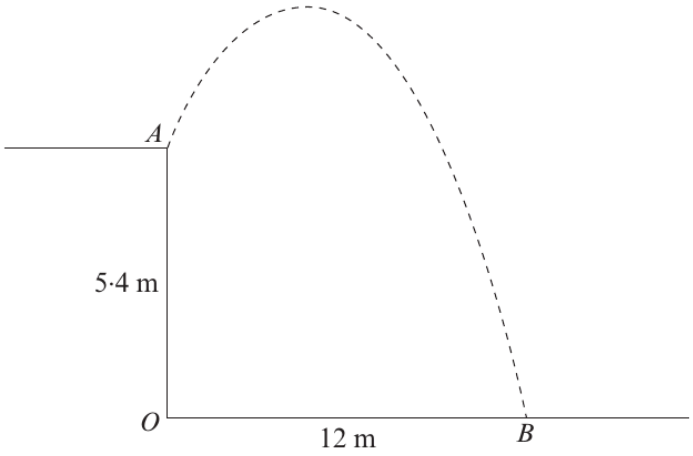
6. A stone is thrown from the top of a vertical cliff, 100 m above sea level. The initial velocity of the stone is $6{\cdot}5\,\text{ms}^{-1}$ at an angle α above the horizontal, where $\tan\alpha = \frac{5}{12}$.

(a) Find the time taken for the stone to reach the sea. Give your answer correct to two decimal places. [5]

(b) Calculate the horizontal distance from the bottom of the cliff to the point where the stone hits the sea. [2]

(c) Calculate the magnitude and direction of the velocity with which the stone hits the sea. [7]

6. A pebble is projected from a point A which is 5·4 m vertically above a point O on horizontal ground.



The initial velocity of the pebble is V ms^{-1} at an angle α above the horizontal, where $\tan\alpha = \frac{3}{4}$. The pebble hits the ground at the point B which is at a distance of 12 m from O.

The time of flight of the pebble is T s.

(a) Write down the horizontal component and the vertical component of the initial velocity of the pebble in terms of V. [2]

(b) Show that $VT = 15$. [2]

(c) Find the value of T and hence find the value of V. [4]

(d) Determine the speed of the pebble as it hits the ground at B. [5]

TURN OVER

3. A person throws a ball from a point A to hit a vertical pole, which is placed at a horizontal distance of 9 m from A. The point A is 1 m above the horizontal ground. The ball is projected with initial speed $15\,\text{ms}^{-1}$ at an angle α above the horizontal, where $\tan\alpha = \frac{3}{4}$.

(a) Given that the ball hits the pole at a point B,

(i) find the time taken for the ball to reach B,

(ii) determine the height of B above the ground. [7]

(b) Given that the ball misses the pole and hits the ground, calculate the speed with which it hits the ground. [5]

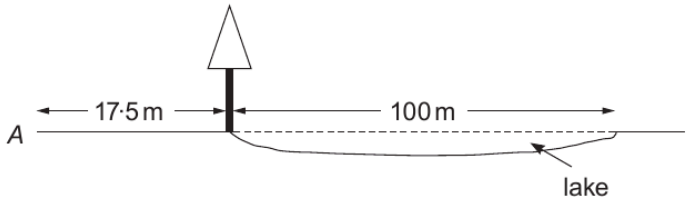
5. A player kicks a ball from a point A on horizontal ground so that 2·5 seconds later the ball just clears a bar at a point B. The point B is 3 m above the ground. The horizontal distance of B from A is 42 m.

(a) Calculate the horizontal and vertical components of the initial velocity of the ball. [4]

(b) Find the magnitude of the velocity of the ball and the angle that the direction of the velocity makes with the horizontal as it passes the point B. [6]

(c) Determine the horizontal distance from B to the point where the ball first hits the ground again. [3]

6. A golfer hits a ball from a point A with initial velocity of $35\,\text{ms}^{-1}$ at an angle α above the horizontal where $\sin\alpha = 0{\cdot}8$. The ball passes over a tree which is growing in front of a lake. The lake is 100 m wide, as shown in the diagram. The tree is at a horizontal distance of 17·5 m from A.



(a) Determine whether or not the golf ball will fall into the lake. [6]

(b) Find the magnitude and direction of the velocity of the ball as it passes over the tree. [7]

2. A particle is projected from horizontal ground with speed $24{\cdot}5\,\text{ms}^{-1}$ in a direction inclined at an angle of 30° above the horizontal.

(a) Calculate the horizontal range of the particle. [6]

(b) Determine the maximum height reached by the particle. [3]

(c) Write down the speed and the direction of motion of the particle as it hits the ground. [1]

4. A and B are points a distance 18 m apart on horizontal ground. An object P is projected from A towards B with velocity 15 ms^{-1} at an angle of 60° to the horizontal. Simultaneously, another object Q is projected from B towards A with velocity v ms^{-1} at an angle of 30° to the horizontal. The objects collide.

(a) Find the value of v. [5]

(b) Show that the time from projection to collision is 0·6 seconds. [3]

(c) Determine the speed of the object P just before collision. [4]

END OF PROJECTILE MOTION PACK

Source: WJEC M2 (2008 modular spec) · 2011–2017
Curated for WJEC Maths 2017 spec A2 Unit 4 — Topic 9 (2.4.6)