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GCE A LEVEL – APPLIED MATHEMATICS B QUESTION PACK

0980-01 (Legacy M1) · New spec Unit 4 Topic 7 · A2 unit, 15% of A-level, 80 marks, 1h 45min paper

REVISE

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MATHEMATICS – APPLIED B · FRICTION ON INCLINED PLANES

Friction on Inclined Planes (Limiting Equilibrium and Dynamics)

Friction on inclined planes from the legacy WJEC M1 papers (2011-2017). Limiting equilibrium, finding coefficient of friction, blocks on the point of slipping, and dynamics with friction up/down slopes

LEGACY 2008 SPECIFICATION

Estimated time for entire question pack: ~1 hours 29 minutes

Derived from the legacy M1 paper's pace of ~1.25 min/mark (71 marks over 8 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 M1 papers (2008 modular spec) that maps onto new-spec A2 Unit 4 Topic 7 (2.4.7).

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 Q6	10	
2	Jan 12 Q3	10	
3	Jun 12 Q5	9	
4	Jan 13 Q5	9	
5	Jan 14 Q4	8	
6	Jun 15 Q2	8	
7	Jun 16 Q7	8	
8	Jun 17 Q7	9	
Total		71	

Friction on Inclined Planes (Limiting Equilibrium and Dynamics) – what the new spec asks

WJEC GCE A Level Mathematics (from 2017) · Unit 4: Applied Mathematics B · Topic 2.4.7.

Friction model 2.4.7

- Friction acts opposite to motion (or tendency to move).
- Static friction satisfies $F \leq \mu R$; limiting friction $F = \mu R$ at the point of slipping.
- R = normal reaction = component of weight perpendicular to the slope.

Inclined plane equilibrium 2.4.7

- Resolve perpendicular to slope: $R = mg \cos \alpha$ (no force along normal otherwise).
- Resolve along slope: balance friction, applied force and $mg \sin \alpha$.
- Range of tensions / forces holding a block on a slope: weight \pm limiting friction.

Friction on Inclined Planes in one page

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

Friction model

Friction acts opposite to motion (or tendency to move).

$F \leq \mu R$ in general; at the point of slipping $F = \mu R$ (limiting friction).

Slope geometry

For a slope at angle α : weight components are $mg \sin \alpha$ along (down) the slope and $mg \cos \alpha$ perpendicular.

$R = mg \cos \alpha$ when no other forces have a perpendicular component.

On the point of slipping (down)

Block about to slip down: friction acts *up* the slope, at its limit μR .

Equation: $\mu R + (\text{any helping force}) = mg \sin \alpha$.

On the point of slipping (up)

Applied force pushing up, about to slip up: friction acts *down* the slope.

Equation: $T = mg \sin \alpha + \mu R$.

Range of tensions / forces

Block in equilibrium on slope with rope: T_{\min} and T_{\max} correspond to about-to-slip-down and about-to-slip-up.

$T_{\min} = mg \sin \alpha - \mu R$ (clip to 0 if negative).

$T_{\max} = mg \sin \alpha + \mu R$.

Dynamics with friction

Block actually moving: friction is kinetic, $F = \mu R$, opposite to motion.

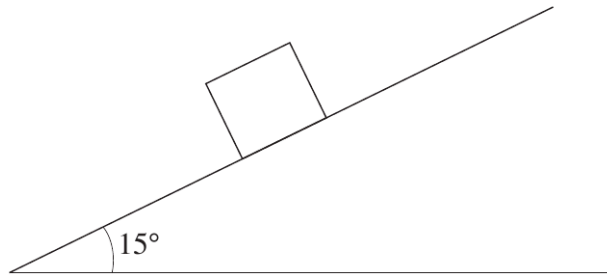
Newton II along slope: $F_{\text{net}} = ma$ with friction subtracted.

SECTION T7

Friction on Inclined Planes (Limiting Equilibrium and Dynamics)

Questions 1–8 · 71 marks

6. The diagram shows an object, of mass 8 kg, on a rough plane inclined at an angle of 15° to the horizontal.



- (a) Given that the object is at rest, calculate the least possible value of the coefficient of friction. Give your answer correct to two decimal places. [6]
- (b) Given that the coefficient of friction is 0.1, find the acceleration of the object down the plane. [4]

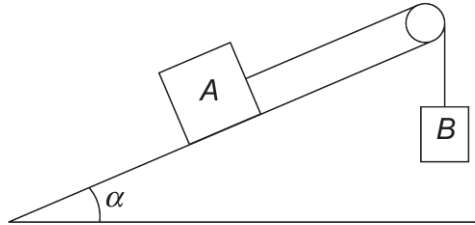
3. A rough plane is inclined at an angle α to the horizontal where $\sin\alpha = \frac{3}{5}$. A body of mass 80 kg lies on the plane. The coefficient of friction between the body and the plane is μ .
- (a) Find the normal reaction of the plane on the body. [2]
- (b) The body is on the point of slipping down the plane. Find the value of μ . [4]
- (c) Calculate the magnitude of the force acting along a line of greatest slope that will move the body up the plane with an acceleration of 0.7 ms^{-2} . [4]

5. A sledge, of mass 39 kg, moves on a rough slope inclined at an angle α to the horizontal, where $\tan \alpha = \frac{5}{12}$. The coefficient of friction between the sledge and the slope is 0.3.
- (a) Given that the sledge is moving freely down a line of greatest slope, calculate the magnitude of the acceleration of the sledge. Give your answer correct to 2 decimal places. [6]
- (b) Given that the sledge is being pulled up the slope with acceleration 0.4 ms^{-2} by means of a rope parallel to a line of greatest slope, find the tension in the rope. [3]

5. An object of mass 75 kg lies on a rough plane, which is inclined at an angle of 25° to the horizontal. The coefficient of friction between the object and the plane is 0.3. A force of magnitude T N acts on the object in a direction parallel to a line of greatest slope of the plane.
- (a) Given that the object is just prevented from sliding down the plane, calculate the value of T . [6]
- (b) Given that $T = 0$, find the magnitude of the acceleration of the object. [3]

4. An object of mass 60 kg lies on a rough plane inclined at an angle of 25° to the horizontal. The coefficient of friction between the plane and the object is denoted by μ . Initially, the object is held at rest. It is then released.
- (a) When $\mu = 0.3$, the object slides down the plane. Calculate
- (i) the magnitude of the frictional force,
 - (ii) the acceleration of the object. [5]
- (b) Given that when the object is released it remains stationary, calculate the least possible value of μ . [3]

2. The diagram shows a body A lying on a rough plane. The plane is inclined at an angle α to the horizontal, where $\sin \alpha = \frac{5}{13}$. Body A is connected by a light inextensible string passing over a light smooth pulley to another body B , which is hanging freely. The masses of A and B are 4 kg and 5 kg respectively.



The system is in equilibrium with A on the point of moving up the plane.

Show that the coefficient of friction between the body A and the plane is $\frac{15}{16}$.

[8]

7. A sledge of mass 12 kg is being pulled up a rough slope, inclined at an angle of 20° to the horizontal, by a rope which is inclined at an angle of 10° to the slope. The tension in the rope is constant at 80 N. The coefficient of friction between the slope and the sledge is 0.2.
- (a) Calculate the frictional force on the sledge. [4]
- (b) Determine the magnitude of the acceleration of the sledge. [4]

TURN OVER

7. An object of mass 45 kg lies on a rough plane inclined at an angle α to the horizontal where $\tan \alpha = \frac{3}{4}$. A rope, attached to the object, is held parallel to the line of greatest slope of the plane. The coefficient of friction between the plane and the object is 0.5. The object remains stationary on the plane. Find the least and the greatest possible values of the tension in the rope. [9]

END OF FRICTION ON INCLINED PLANES PACK

Source: WJEC M1 (2008 modular spec) · 2011–2017
Curated for WJEC Maths 2017 spec A2 Unit 4 – Topic 7 (2.4.7)

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