

inkMaths

ANSWER BOOK

Equilibrium, suspension, toppling and sliding

Further Mechanics 2 · Year FM

6 questions · 20 marks

NAVY EDITION

SECTION A · Warm-up

- A1** Vertically below the point of suspension. If it were not, the weight would have a moment about the pivot and the body would turn until it was. That single fact fixes the angle at which any suspended lamina hangs.
- A2** The line from the pivot to G makes an angle $\arctan(2/3)$ with the vertical, so the edge tilts by 33.7° . Dividing the other way round would give 56.3° , the angle to the horizontal, so state which angle you have found.

SECTION B · Standard

- B1** Toppling: the base half-width is 0.25 and the height of G is 0.6, so $\tan \theta = 0.25/0.6 = 0.4167$ and $\theta = 22.6^\circ$. Sliding: $\tan \theta = \mu = 0.5$, so $\theta = 26.6^\circ$. The smaller angle comes first, so the block topples at 22.6° .
- B2** They coincide when $\mu = a/h = 0.25/0.6 = 0.4167$. Below that the friction limit is reached first and the block slides; above it the weight line leaves the base first and the block topples. A smoother surface protects a tall block from falling over, which is not intuitive.
- B3** The normal reaction acts somewhere within the area of contact. For equilibrium its moment about the centre of mass must balance, which is only possible if the vertical through the centre of mass meets the base. Once it falls outside, no position of the reaction can balance the moments and the block turns. Height matters only through where that vertical line lands.

SECTION C · Stretch

- C1** Toppling needs $\tan \theta = 0.3/(h/2) = 0.6/h$; sliding needs $\tan \theta = 0.6$. Toppling comes first when its angle is smaller, that is $0.6/h < 0.6$, so $h > 1 \text{ m}$. A cylinder taller than a metre falls over; a shorter one slides away. At exactly one metre the two happen together.