Sliding or Toppling under an Applied Force

Specification: AQA 7367: ME5 (sliding and toppling) · Edexcel 9FM0: FM2 Further centres of mass (sliding and toppling)

HOMEWORK Consolidation

1 A uniform crate, 0.9 m wide and 1.8 m tall, of weight 360 N, stands on rough horizontal ground ($\mu = 0.3$). A horizontal force P acts at the top edge of its back face. Does it slide or topple first, and at what value of P?

AQA 7367 ME5 (sliding or toppling) · Edexcel FM2 (Further centres of mass: sliding and toppling)

2 A uniform block of mass 20 kg, 1.0 m wide and 0.5 m tall, stands on rough horizontal ground ($\mu = 0.5$). A horizontal force P acts at the top edge of its back face. Does it slide or topple first, and at what value of P? Take $g = 9.8$ m s^{-2}.

AQA 7367 ME5 (sliding or toppling) · Edexcel FM2 (Further centres of mass: sliding and toppling)

3 A uniform block of weight W, 0.6 m wide and 1.2 m tall, stands on rough horizontal ground ($\mu = 0.4$). A horizontal force pushes its back face at a height of h metres. Find the range of values of h for which it topples before it slides.

AQA 7367 ME5 (range of values) · Edexcel FM2 (sliding and toppling)

4 A uniform solid cylinder of radius 0.2 m and height 0.5 m stands on its plane face on rough horizontal ground. A horizontal force acts at a point on the rim of its top face, in the vertical plane through the axis. Find the range of values of μ for which it slides before it topples.

AQA 7367 ME5, ME2 (uniform solids) · Edexcel FM2 (solids: toppling) · range

5 A uniform block, 0.5 m wide and 1.0 m tall, of weight 120 N, stands on rough horizontal ground ($\mu = 0.6$). A rope attached to the top edge of its front face pulls forwards at $25°$ above the horizontal. Does it slide or topple first, and at what tension?

AQA 7367 ME5 (force at an angle) · Edexcel FM2 (sliding and toppling)

6 A uniform block, 0.8 m wide and 0.8 m tall, of weight 100 N, stands on rough horizontal ground ($\mu = 0.5$). A force P acts at the top edge of its back face, at $30°$ above the horizontal, towards the front edge. Does it slide or topple first, and at what value of P?

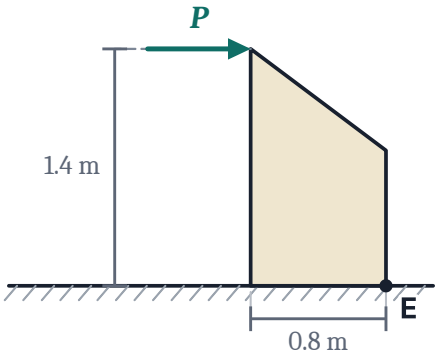
AQA 7367 ME5 (force at an angle) · Edexcel FM2 (sliding and toppling)

7 A uniform lamina is a square of side 0.8 m with a right-angled triangle on top (horizontal side the whole 0.8 m top edge, right angle at the top left, vertical side 0.6 m). It weighs 110 N and stands on rough horizontal ground ($\mu = 0.3$).

(a) Show that its centre of mass is $\frac{4}{11}$ m from the left-hand edge.

(b) A horizontal force P pushes to the right at the top vertex. Does it slide or topple first, and at what P?

AQA 7367 ME5, ME2 (composite lamina) · Edexcel FM2 (composite lamina: toppling)



8 A uniform lamina of weight W is bounded by $y = \sqrt{x}$, the x-axis and the line $x = 4$ (lengths in metres). It stands in a vertical plane with its straight edge along the x-axis on rough horizontal ground.

(a) Find $\bar{x}$.

(b) A horizontal force P acts at its top corner $(4, 2)$, pulling away from O. Show that the lamina is about to topple when $P = 0.8W$.

(c) Find the range of values of μ for which it slides before it topples.

AQA 7367 ME5, ME3 (lamina by integration) · Edexcel FM2 (Further centres of mass)

9 A uniform solid cone of weight 40 N, base radius 0.25 m and height 1.0 m, stands on its base on rough horizontal ground ($\mu = 0.2$). A horizontal force P acts at its vertex. Does it slide or topple first, and at what value of P?

AQA 7367 ME5, ME2 (uniform solids) · Edexcel FM2 (solids: toppling)

10 A uniform block, 0.6 m wide and 1.5 m tall, stands on rough horizontal ground. A horizontal force at the top edge of its back face is increased until the block is about to slide and about to topple at the same moment. Find the coefficient of friction.

AQA 7367 ME5 (range of values) · Edexcel FM2 (sliding and toppling)

11 *AQA-style*. A uniform block of weight W is $2a$ wide and $3a$ tall and stands on rough horizontal ground; the coefficient of friction is μ. A force P acts at the top edge of its back face, at angle θ above the horizontal, towards the front edge E, and P is slowly increased.

(a) Show that the block is about to slide when $P = \mu W/(\cos\theta + \mu \sin\theta)$. [2]

(b) Show that it is about to topple when $P = W/(3\cos\theta + 2\sin\theta)$. [2]

(c) Given that $\tan\theta = 3/4$ and $\mu = 0.25$, determine whether the block slides or topples first. [3]

AQA 7367 ME5 (force at an angle) · Edexcel FM2 (sliding and toppling) · AQA-style

12 *Edexcel-style*. A uniform lamina is a rectangle ABCD ($AB = 4a$, $BC = 2a$) with a square of side $2a$ on the left half of DC, top left corner F. It has weight W and stands with AB on rough horizontal ground (coefficient of friction μ).

(a) Show that its centre of mass is $\dfrac{5a}{3}$ from AF. [2]

(b) A horizontal force P at F pushes in the direction AB. Show that it is about to topple about B when $P = 7W/12$. [2]

(c) Given that it slides first, find the range of values of μ. [2]

AQA 7367 ME5, ME2 (composite lamina) · Edexcel FM2 (composite lamina: toppling) · Edexcel-style