

## STEP II, 2004, Q4 MS

*Q4* It is important to realise at the outset that  $\alpha$  is a constant defined by  $a$  and  $b$  and that  $\beta$  is a constant defined by  $a$ ,  $b$  and  $w$ . Variable angles  $\theta/\phi$  are needed to define the orientation of the rod/table in the general situation.

(i) Clearly, for all  $\theta \in (0, \pi/2)$ , it is necessary that  $f(\theta) \geq L$ , where  $f(\theta) = a \csc \theta + b \sec \theta$ . Setting  $f'(\theta) = 0$  will then lead to the required result.

(ii) Here, for all  $\phi \in (0, \pi/2)$ , it is necessary that  $y \geq l$ , where  $y$  is such that  $b = (y-x) \cos \phi + w \sin \phi$  and  $x$  is such that  $a = x \sin \phi + w \cos \phi$ . (Other formulations are possible.) Elimination of  $x$  leads to  $y = a \csc \phi + b \sec \phi - 2w \csc 2\phi$

Setting  $y'(\phi) = 0$  plus some further working will then produce the required result.



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