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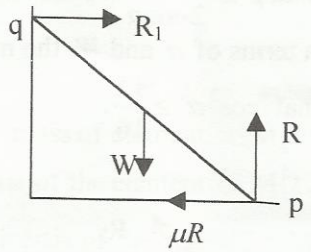
7. **(a)** A uniform ladder [pq], of length $2l$ and weight W, is in equilibrium with end p against a rough horizontal floor and end q against a smooth vertical wall. The ladder makes an angle $\tan^{-1} 2$ with the floor.

(i) Show that the least possible value for μ, the coefficient of friction between the ladder and the floor, is $\frac{1}{4}$.

(ii) If, however, $\mu = \frac{1}{3}$, find, in terms of l, the distance from p of the highest point on the ladder at which a man of weight $2W$ can stand without the ladder slipping.



(i)

{diagram} or $\{R_1 = \mu R \quad \text{and} \quad R = W\}$ — 5

Moments about p:

$W(\ell\cos\alpha) = R_1(2\ell\sin\alpha)$ — 5

$W = R_1(2\tan\alpha)$

$\Rightarrow \quad R_1 = \frac{1}{4}W \quad \text{and} \quad \mu = \frac{1}{4}$ — 5

(ii)

$R_1 = \mu R \quad (= \frac{1}{3}R = W)$

$R = 3W$

Moments about p:

$W(\ell\cos\alpha) + 2W(x\cos\alpha) = R_1(2\ell\sin\alpha)$ — 5

$W\ell + 2Wx = R_1(2\ell\tan\alpha)$

$= 4W\ell$

$\Rightarrow \quad x = \frac{3\ell}{2}$ — 5

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