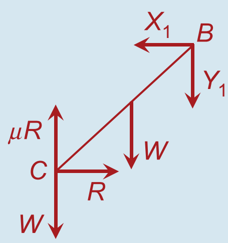
$\Rightarrow F = \frac{1}{2}W + \frac{1}{2}W$

$\Rightarrow F = W$

(ii) An additional force is now applied downwards at C. The force diagram for the BC now looks like this:



Because we are now at limiting friction, the friction force is μR.

Taking moments around B we get:

$W(l \sin \phi) + W\left(\frac{1}{2} \sin \phi\right) + R(l \cos \phi)$

$= \mu R(l \sin \phi)$ ... divide by $l \cos \phi$

$\Rightarrow W \tan \phi + \frac{1}{2}W \tan \phi + R = \mu R \tan \phi$

... $R = \frac{1}{2}W \tan \phi$

$\Rightarrow W \tan \phi + W \tan \phi = \mu\left(\frac{1}{2}W \tan^2 \phi\right)$

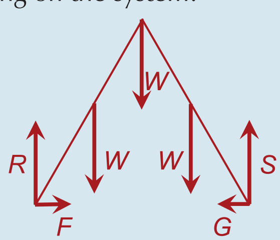
... divide by $W \tan \phi$

$\Rightarrow 2 = \mu\left(\frac{1}{2} \tan \phi\right)$ ... multiply by 2

$\Rightarrow \mu \tan \phi = 4$

$\Rightarrow \mu = \frac{4}{\tan \phi}$

Q. 10. **Note:** The person will need to stand at A to maximise the chance of slipping. Because the system will then be symmetrical, slipping will occur at B and C simultaneously. Here are the forces acting on the system:



Taking moments around C we get:

$W\left(\frac{d}{2}\right) + W(d) + W\left(\frac{3d}{2}\right) = R(2d)$

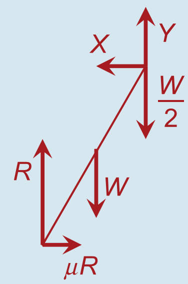
... multiply by $\frac{2}{d}$

$\Rightarrow W + 2W + 3W = 4R$

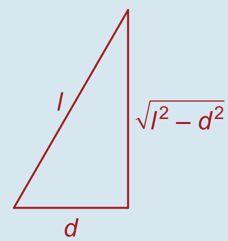
$\Rightarrow 4R = 6W$

$\Rightarrow R = \frac{3}{2}W$

Now, look at the ladder $[AB]$ in isolation. Here are the forces when it is just on the point of slipping:



Lengths



Taking moments around A we get:

$R(d) = W\left(\frac{d}{2}\right) + \mu R\left(\sqrt{l^2 - d^2}\right)$

... $R = \frac{3}{2}W$

$\Rightarrow \frac{3}{2}Wd = \frac{1}{2}Wd + \mu\left(\frac{3}{2}W\right)\sqrt{l^2 - d^2}$

... multiply by $\frac{2}{W}$

$\Rightarrow 3d = d + 3\mu\sqrt{l^2 - d^2}$

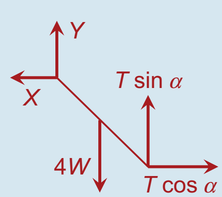
$\Rightarrow 3\mu\sqrt{l^2 - d^2} = 2d$

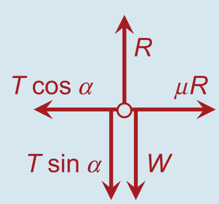
$\Rightarrow \mu = \frac{2d}{3\sqrt{l^2 - d^2}}$

$\Rightarrow$ In order to avoid slipping

$\mu \geq 2\frac{d}{3\sqrt{l^2 - d^2}}$

Q. 11. (i) **Rod $[AB]$** **Ring C**





Taking moments about A we get:

$4W(l \cos\alpha) = T \cos \alpha(2l \sin \alpha) +$
$T \sin \alpha(2l \cos \alpha)$

... divide by $2l \cos \alpha$

$\Rightarrow 2W = T \sin \alpha + T \sin \alpha$

$\Rightarrow 2W = 2T \sin \alpha$

$\Rightarrow W = T \sin \alpha$