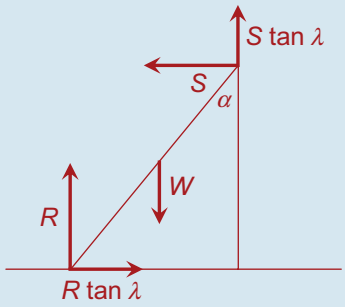
Q. 9. (i) The normal reaction, R, and the limiting friction, F, acting on a body which is either moving or on the point of moving, can be added to form a resultant. The angle between this resultant and the normal reaction is the **angle of friction**.

(ii)



Let the length of the ladder be $2l$

(1) $R + S\tan\lambda = W$

$\Rightarrow R = W - S\tan\lambda$

(2) $R\tan\lambda = S$

(3) $Wl\sin\alpha = S(2l\cos\alpha) + S\tan\lambda(2l\sin\alpha)$

$\Rightarrow S(2\cos\alpha + 2\tan\lambda\sin\alpha) = W\sin\alpha$

$\Rightarrow S = \dfrac{W\sin\alpha}{2(\cos\alpha + \tan\lambda\sin\alpha)}$

(2) $(W - S\tan\lambda)\tan\lambda = S$

$\Rightarrow W\tan\lambda - S\tan^2\lambda = S$

$\Rightarrow S(1 + \tan^2\lambda) = W\tan\lambda$

$\Rightarrow S = \dfrac{W\tan\lambda}{1 + \tan^2\lambda}$

$\Rightarrow \dfrac{W\sin\alpha}{2(\cos\alpha + \tan\lambda\sin\alpha)} = \dfrac{W\tan\lambda}{1 + \tan^2\lambda}$

$\Rightarrow (1 + \tan^2\lambda)\sin\alpha = 2\tan\lambda(\cos\alpha + \tan\lambda\sin\alpha)$

$\Rightarrow \sin\alpha + \tan^2\lambda\sin\alpha = 2\tan\lambda\cos\alpha + 2\tan^2\lambda\sin\alpha$

$\Rightarrow \tan^2\lambda\sin\alpha + 2\tan\lambda\cos\alpha = \sin\alpha$ … divide by $\cos\alpha$

$\Rightarrow \tan^2\lambda\tan\alpha + 2\tan\lambda = \tan\alpha$

$\Rightarrow \tan\alpha(1 - \tan^2\lambda) = 2\tan\lambda$

$\Rightarrow \tan\alpha = \dfrac{2\tan\lambda}{1 - \tan^2\lambda}$

$\Rightarrow \tan\alpha = \tan 2\lambda$

$\Rightarrow \alpha = 2\lambda$