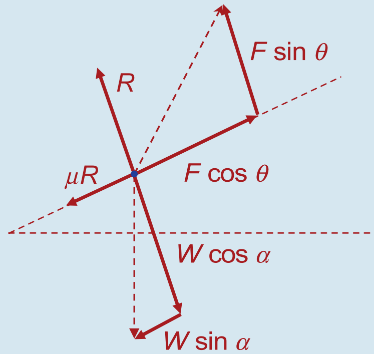
**Q. 8.** $\mu = \tan \lambda$

The diagram shows resolved forces acting on the particle.




$R + F\sin\theta = W\cos\alpha$

$\Rightarrow R = W\cos\alpha - F\sin\theta$

$\mu R + W\sin\alpha = F\cos\theta$

$\Rightarrow R\tan\lambda = F\cos\theta - W\sin\alpha$

$\Rightarrow R = \dfrac{F\cos\theta - W\sin\alpha}{\tan\lambda}$

$\Rightarrow W\cos\alpha - F\sin\theta = \dfrac{F\cos\theta - W\sin\alpha}{\tan\lambda}$

$\Rightarrow W\cos\alpha - F\sin\theta = (F\cos\theta - W\sin\alpha)\left(\dfrac{\cos\lambda}{\sin\lambda}\right)$ ... multiply by $\sin\lambda$

$\Rightarrow W\cos\alpha\sin\lambda - F\sin\theta\sin\lambda = F\cos\theta\cos\lambda - W\sin\alpha\cos\lambda$

$\Rightarrow F(\cos\theta\cos\lambda + \sin\theta\sin\lambda) = W(\cos\alpha\sin\lambda + \sin\alpha\cos\lambda)$

$\Rightarrow F\cos(\theta - \lambda) = W\sin(\alpha + \lambda)$

$\Rightarrow F = \dfrac{W\sin(\alpha + \lambda)}{\cos(\theta - \lambda)}$

(i) Force acting up along the plane $\Rightarrow \theta = 0$

$\Rightarrow F = \dfrac{W\sin(\alpha + \lambda)}{\cos(-\lambda)}$ ... $\cos(-\lambda) = \cos\lambda$

$\Rightarrow F = \dfrac{W\sin(\alpha + \lambda)}{\cos\lambda}$

(ii) Horizontal force $\Rightarrow \theta = -\alpha$

$\Rightarrow F = \dfrac{W\sin(\alpha + \lambda)}{\cos(-\alpha - \lambda)}$

$= \dfrac{W\sin(\alpha + \lambda)}{\cos[-(\alpha + \lambda)]}$

$= \dfrac{W\sin(\alpha + \lambda)}{\cos(\alpha + \lambda)}$

$= W\tan(\alpha + \lambda)$

(iii) $F = \dfrac{W\sin(\alpha + \lambda)}{\cos(\theta - \lambda)}$

Minimum force will occur when $\cos(\theta - \lambda)$ is at its maximum value, i.e. $\cos(\theta - \lambda) = 1$

$\Rightarrow F_{MIN} = W\sin(\alpha + \lambda)$.