

STEP II, 2004, Q9 MS

Q9 For each of the two given situations, it is essential that a properly annotated diagram consistent with a possible state of equilibrium is supplied.

In the first situation, taking moments about the point of contact of the hemisphere with the floor leads to

$$mgr \cos \alpha = Mg(p \sin \alpha - q \cos \alpha) \Rightarrow \tan \alpha = (Mq + mr)/Mp.$$

A similar argument applied to the second situation leads to

$$mgr \cos \beta = Mg(p \sin \beta + q \cos \beta) \Rightarrow \tan \beta = (mr - Mq)/Mp.$$

It is then easy to see that

$$\tan(\alpha + \beta) = (\tan \alpha + \tan \beta)/(1 - \tan \alpha \tan \beta) = 2mMrp/[M^2(p^2 + q^2) - m^2r^2].$$

If the sense of the rotation is taken into account then β should be changed to $-\beta$.



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