

STEP III, 2002 Q10

- 10 A light hollow cylinder of radius a can rotate freely about its axis of symmetry, which is fixed and horizontal. A particle of mass m is fixed to the cylinder, and a second particle, also of mass m , moves on the rough inside surface of the cylinder. Initially, the cylinder is at rest, with the fixed particle on the same horizontal level as its axis and the second particle at rest vertically below this axis. The system is then released. Show that, if θ is the angle through which the cylinder has rotated, then

$$\ddot{\theta} = \frac{g}{2a} (\cos \theta - \sin \theta) ,$$

provided that the second particle does not slip.

Given that the coefficient of friction is $\frac{3 + \sqrt{3}}{6}$, show that the second particle starts to slip when the cylinder has rotated through 60° .



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