

## STEP III, 2004, Q9

- 9 A circular hoop of radius  $a$  is free to rotate about a fixed horizontal axis passing through a point  $P$  on its circumference. The plane of the hoop is perpendicular to this axis. The hoop hangs in equilibrium with its centre,  $O$ , vertically below  $P$ . The point  $A$  on the hoop is vertically below  $O$ , so that  $POA$  is a diameter of the hoop.

A mouse  $M$  runs at constant speed  $u$  round the rough inner surface of the lower part of the hoop. Show that the mouse can choose its speed so that the hoop remains in equilibrium with diameter  $POA$  vertical.

Describe what happens to the hoop when the mouse passes the point at which angle  $AOM = 2 \arctan \mu$ , where  $\mu$  is the coefficient of friction between mouse and hoop.



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