

STEP III, 2013 , Q10

- 10 A uniform rod AB has mass M and length $2a$. The point P lies on the rod a distance $a - x$ from A . Show that the moment of inertia of the rod about an axis through P and perpendicular to the rod is

$$\frac{1}{3}M(a^2 + 3x^2).$$

The rod is free to rotate, in a horizontal plane, about a fixed vertical axis through P . Initially the rod is at rest. The end B is struck by a particle of mass m moving horizontally with speed u in a direction perpendicular to the rod. The coefficient of restitution between the rod and the particle is e . Show that the angular velocity of the rod immediately after impact is

$$\frac{3mu(1+e)(a+x)}{M(a^2+3x^2)+3m(a+x)^2}.$$

In the case $m = 2M$, find the value of x for which the angular velocity is greatest and show that this angular velocity is $u(1+e)/a$.



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