Karlsruhe Institute of Technology - International Department GmbH

Pre-Semester 2010 - Physics Course - Extra Tutorial

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1. Totally inelastic collision - mathematical pendulum

Consider a point mass M attached to a *massless* rod with length l which is itself fixed at the ceiling (for short: a "mathematical pendulum"). A bullet of mass m moves horizontally with velocity v toward the point mass. After the impact both, bullet and point mass, stick together.

(a) What is the total (linear) momentum shortly before the impact?

(b) What is the velocity v' of the combined object shortly after the impact?

(c) What is the kinetic energy shortly after the impact and how much energy Q has been converted into heat?

(d) What is the maximal angle $\alpha_{\max}$ to the vertical by which the rod is deflected?

2. Totally inelastic collision - physical pendulum

Now we adress the similar, more realistic problem where the rod is not massless. In fact, now the pendulum may have any arbitrary shape. For this, we take all angular quantities (like angular momentum) with respect to the (fixed) axis of rotation. We denote the pendulum's moment of inertia by Θ, its mass by M and the distance of its center of mass to the axis by s.

Again, this pendulum is hit by the same, sticky, bullet at a point which is located directly below the axis, at a distance l.

(a) What is the total angular momentum shortly before the impact?

(b) What is the moment of inertia Θ' of the combined object?

(c) What is its angular velocity ω' shortly after the impact?

(d) What is the kinetic energy shortly after the impact and how much energy Q has been converted into heat?

(e) Does the combined object have the same center of mass as the original pendulum? Where is it now? What is its new distance s' to the axis?

(f) What is the maximal angle $\alpha_{\max}$ to the vertical by which the center of mass is deflected?

(g) Just out of curiosity: What is the moment of inertia Θ'_{cm} of the combined object with respect to an axis through its *center of mass* parallel to the original axis? (*advanced!*)