Homework #12

Donald Aingworth IV

November 13, 2024

Problem 1

In 1932, James Chadwick fired neutrons of unknown speed and mass into different substances. He found that protons (of mass 1 u) were given a speed 7.5 times that given to nitrogen nuclei (of mass 14 u). If the collisions were elastic and head on, what can you deduce about the mass of the neutron?

Solution

Problem 2

A one-dimensional inelastic collision may be characterized by a coefficient of restitution e that relates the relative velocities before and after the collision: $(v_{1,f} - v_{2,f}) = -e(v_{1,i} i v 2, i)$. Show that the final velocities are:

$$v_{1,f} = \frac{(m_1 - em_2)v_{1,i} + m_2(1+e)v_{2,i}}{m_1 + m_2}$$

$$v_{2,f} = \frac{m_1(1+e)v_{1,i} + (m_2 - em_1)v_{2,i}}{m_1 + m_2}$$

(Hint, kinetic energy is not conserved. You will need two equations so solve for the two unknowns.)

Solution

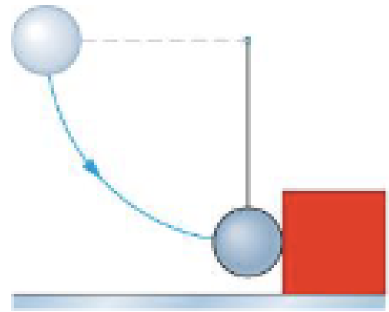
Problem 3

An alpha particle (^{4}He) undergoes an elastic collision with a stationary uranium nucleus (^{235}U). What percent of the kinetic energy of the alpha particle is transferred to the uranium nucleus? Assume the collision is one dimensional.

Solution

Problem 4

A steel ball of mass 0.500 kg is fastened to a cord that is 70.0 cm long and fixed at the far end. The ball is then released when the cord is horizontal. At the bottom of its path, the ball strikes a 2.50 kg steel block initially at rest on a frictionless surface. The collision is elastic. Find (a) the speed of the ball and (b) the speed of the block, both just after the collision.



Solution

Problem 5

The platter in a belt drive turntable is driven by a belt that wraps around a hub, of radius 3.00 cm, below the platter and around the shaft of the motor. If the platter rotates at 33.3 rpm and the motor rotates at 60 rpm, what is the required radius of the shaft?

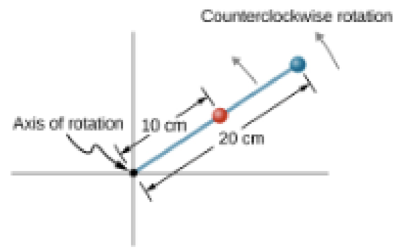
Solution

Problem 6

At t = 0, a flywheel has an angular velocity of 4.70 rad/s, a constant angular acceleration of -0.24 rad/s^2, and a reference line at $\theta_0 = 0$. (a) Through what maximum angle θ_{max} will the reference line turn in the positive direction? What are the (b) first and (c) second times the reference line will be at $\theta = \frac{1}{2}\theta_{max}$? At what (d) negative time and (e) positive time will the reference line be at θ = -10.5 rad? (f) Graph θ versus t, and indicate your answers.

Solution

Problem 7



The angular position of a rod varies as 20.0 t^2 radians starting from time t = 0 . The rod has two beads on it as shown in the following figure, one at 10.0 cm from the rotation axis and the other at 20.0 cm from the rotation axis. (a) What is the instantaneous angular velocity of the rod at t = 5.00 s? (b) What is the angular acceleration of the rod? (c) What are the tangential speeds of the beads at t = 5.00 s? (d) What are the tangential accelerations of the beads at t = 5.00 s? (e) What are the centripetal accelerations of the beads at t = 5.00 s?

Solution

Problem 8

The angular acceleration of a rotating rigid body is given by $\alpha = (A - Bt)$, where A = 2.00 rad/s^2 and B = 3.00 rad. If the body starts rotating from rest at t = 0 , (a) what is the angular velocity? (b) Angular position? (c) What angle does it rotate through in 10.0 s? (d) Where does the vector perpendicular to the axis of rotation indicating 0° at t = 0 lie at t = 10.0 s ?

Solution

Section (a)

We remark that since $\alpha = \frac{d\omega}{dt}$, we can manipulate it to know that $\omega = \int \alpha \, dt$. We also know that $\omega = 0$ at $t = 0$.

$$\begin{aligned}
\alpha &= A - Bt \\
\omega &= \int \alpha \, dt = \int_0^t A - Bt' \, dt' = \left[At' - \frac{Bt'^2}{2} \right]_0^t \\
&= At - \frac{1}{2}Bt^2 = \boxed{2.00t - \frac{3}{2}t^2}
\end{aligned}$$

Section (b)

We remark that since $\omega = \frac{d\theta}{dt}$, we can manipulate it to know that $\theta = \int \omega \, dt$. We also assume that $\theta = 0$ at $t = 0$.

$$\begin{aligned}
\alpha &= A - Bt \\
\omega &= At - \frac{1}{2}Bt^2 \\
\theta &= \int \omega \, dt = \int_0^t At' - \frac{1}{2}Bt'^2 \, dt' = \left[\frac{At'^2}{2} - \frac{Bt'^3}{6} \right]_0^t \\
&= \frac{At^2}{2} - \frac{Bt^3}{6} = \boxed{t^2 - \frac{1}{2}t^3}
\end{aligned}$$

Section (c)