IF THE LARGE BALL REBOUNDS ELASTICALLY FROM THE FLOOR

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•••69 A small ball of mass m is aligned above a larger ball of mass $M = 0.63$ kg (with a slight separation, as with the baseball and basketball of Fig. 9-68*a*), and the two are dropped simultaneously from a height of $h = 1.8$ m. (Assume the radius of each ball is negligible relative to h.) (a) If the larger ball rebounds elastically from the floor and then the small ball rebounds elastically from the larger ball, what value of m results in the larger ball stopping when it collides with the small ball? (b) What height does the small ball then reach (Fig. 9-68*b*)?

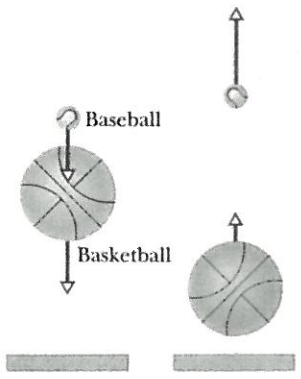


Fig. 9-68 Problem 69.

(WHICH DOES NOT MOVE), THEN IT REBOUNDS WITH THE SAME SPEED IT IMPACTS IT WITH, v_0.

THIS CAN BE FOUND WITH $W^{net\ ext}_{sys} = \Delta E^{tot}_{sys}$ SYSTEM = BALL + EARTH

$\Rightarrow 0 = \Delta E^{tot}_{MECH} \Rightarrow \Delta K = -\Delta U$

$\Rightarrow \frac{1}{2}mv_0^2 - 0 = -mg\Delta y$

Where i = the drop @ height $y = h$ & f = the floor, $y = 0$.

$\frac{1}{2}mv_0^2 = -mg(-h) \Rightarrow v_0 = \sqrt{2gh}$

ELASTIC COLLISION BETWEEN THE LARGE BALL WITH $\vec{v}_{1i} = v_0(+\hat{y})$ AND THE SMALL BALL WITH $\vec{v}_{2i} = v_0(-\hat{y})$. REMEMBER THEY HAVE THE SAME SPEED SINCE v_0 does NOT DEPEND ON MASS AND THEIR SIZES (R & r) ARE TRIVIAL COMPARED TO h.

WE ARE TOLD THAT $\vec{v}_{1f} \equiv 0$. RATHER THAN SUBSTITUTING INTO THE SOLUTION WE DERIVED IN CLASS BY APPLYING CONSERVATION OF MOMENTUM & KINETIC ENERGY (SEE OTHER POSTED SOLUTION) WE WILL USE THE GENERAL RESULT THAT WE PROVED WAS TRUE FOR ANY ELASTIC COLLISION: THE RELATIVE VELOCITY OF APPROACH = −(THE RELATIVE VELOCITY OF RECESSION) OR ...

$v^i_{1,2} = -v^f_{1,2}$ or $v_{1i} - v_{2i} = -(v_{1f} - v_{2f})$ THIS IS EASY TO REMEMBER, THE GENERAL SOLN IS NOT!

$\Rightarrow +v_0 - (-v_0) = -(0 - v_{2f}) \Rightarrow v_{2f} = +2v_0$

NOW APPLY THE CONSERVATION OF MOMENTUM: $\vec{P}^{tot}_i = \vec{P}^{tot}_f$

$m_1v_{1i} + m_2v_{2i} = m_1v_{1f} + m_2v_{2f}$

a) $\Rightarrow M(+v_0) + m(-v_0) = M\,0 + m(+2v_0) \Rightarrow \boxed{M = 3m}$

b) $W^{net\ ext}_{sys} = \Delta E^{tot}_{sys}$ where SYSTEM = m + Earth & ...

initial = immediately after collision & final = top of m's trajectory.

$\Rightarrow 0 = \Delta E^{tot}_{MECH} \Rightarrow \Delta K = -\Delta U \Rightarrow K_f - K_i = -\Delta(mgy)$

$\Rightarrow \frac{1}{2}m\,0^2 - \frac{1}{2}m(2v_0)^2 = -mg(\Delta y = 0 - H)$

$2mv_0^2 = +mgH \Rightarrow H = 2v_0^2/g = 2\frac{2gh}{g} = 4h$

$$v_{1f} = \frac{m_1 - m_2}{m_1 + m_2}v_{1i} + \frac{2m_2}{m_1 + m_2}v_{2i}$$

$$v_{2f} = \frac{2m_1}{m_1 + m_2}v_{1i} + \frac{m_2 - m_1}{m_1 + m_2}v_{2i}$$