Answer on Question 61694, Physics, Mechanics | Relativity

Question:

A ball of mass $m = 8.0 \cdot 10^{-2}\ kg$ starts from rest and falls vertically downward from a height of $3.0\ m$. After colliding with the ground, it bounces up to a height of $2.0\ m$. The collision takes place over a time interval of $\Delta t = 5.0 \cdot 10^{-3}\ s$. Calculate:

1) the momentum of the ball immediately before and immediately after the collision

2) average force exerted by the ground on the ball

3) impulse imparted to the ball

Solution:

1) Let's first find the velocity of the ball just before it collides with the ground from the Law of Conservation of Energy:

$$PE = KE,$$

$$mgh_1 = \frac{1}{2}mv_1^2,$$

$$v_1 = \sqrt{2gh_1} = \sqrt{2 \cdot 9.8\ \frac{m}{s^2} \cdot 3.0\ m} = 7.67\ \frac{m}{s}.$$

Then, the momentum of the ball immediately before the collision will be:

$$p_1 = mv_1 = 8.0 \cdot 10^{-2}\ kg \cdot 7.67\ \frac{m}{s} = 0.61\ kg\frac{m}{s}.$$

Again using the Law of Conservation of Energy, we can find the velocity of the ball after it bounces from the ground:

$$PE = KE,$$

$$mgh_2 = \frac{1}{2}mv_2^2,$$

$$v_2 = \sqrt{2gh_2} = \sqrt{2 \cdot 9.8\ \frac{m}{s^2} \cdot 2.0\ m} = 6.26\ \frac{m}{s}.$$

Therefore, the momentum of the ball immediately after the collision will be:

$$p_2 = mv_2 = 8.0 \cdot 10^{-2}\ kg \cdot 6.26\ \frac{m}{s} = 0.5\ kg\frac{m}{s}.$$

2) From the definition of the impulse we have:

$$\bar{F}\Delta t = m\Delta v = J = p_1 - p_2.$$

Then, the average force exerted by the ground on the ball will be:

$$\bar{F} = \frac{p_1 - p_2}{\Delta t} = \frac{0.61\ kg\frac{m}{s} - 0.5\ kg\frac{m}{s}}{5.0 \cdot 10^{-3}\ s} = 22\ N.$$

3) The impulse imparted to the ball will be:

$$J = p_1 - p_2 = 0.61\ kg\frac{m}{s} - 0.5\ kg\frac{m}{s} = 0.11\ kg\frac{m}{s}.$$

Answer:

1) $p_1 = 0.61\ kg\frac{m}{s}$, $p_2 = 0.5\ kg\frac{m}{s}$

2) $\bar{F} = 22\ N.$

3) $J = 0.11\ kg\frac{m}{s}.$