Answer on Question #39825 – Physics – Mechanics

1. A ball of mass kg, 5.0*10^-2 starting from rest, falls a height of 4.0 m and then collides with the ground. The ball bounces up to a height of 2.0 m. The collision with the ground takes place over a time 4*10^-3 s. Determine (i) the momentum of the ball immediately before the collision, (ii) the momentum of the ball immediately after the collision and (iii) the average force of the ground on the ball.

$m = 5\cdot 10^{-2}\ kg$

$h_0 = 4\,m$

$h_1 = 2\,m$

$t = 4\cdot 10^{-3}\ s$

$p_0,\ p_1,\ \overline{F} - ?$

Solution.

(i) The velocity of the ball immediately before the collision determines by kinematics of the movement: $h = \dfrac{v_0^{\ 2}}{2g}$, $v_0 = \sqrt{2gh_0}$.

The momentum of the ball immediately before the collision:

$p_0 = mv_0$, $\boxed{p_0 = m\sqrt{2gh}}$.

(ii) If the ball bounces up to a height of 2.0 m, we can calculate its velocity immediately after the collision: $v_1 = \sqrt{2gh_1}$.

So, the momentum of the ball immediately after the collision: $p_1 = mv_1$, $\boxed{p_1 = m\sqrt{2gh_1}}$.

(iii) The average force of the ground on the ball: $\overline{F} = \dfrac{p_1 - (-p_0)}{t}$, $\boxed{\overline{F} = \dfrac{m\sqrt{2g}}{t}\left(\sqrt{h_1} + \sqrt{h_0}\right)}$.

Let check the dimensions.

$$[p_0] = [p_1] = kg\cdot\sqrt{\frac{m}{s^2}\cdot m} = \frac{kg\cdot m}{s},\quad [\overline{F}] = \frac{kg\cdot\sqrt{\frac{m}{s^2}}}{s}\cdot\sqrt{m} = \frac{kg\cdot m}{s^2} = N\,.$$

Let evaluate the quantities.

$$p_0 = 5\cdot 10^{-2}\cdot\sqrt{2\cdot 9.8\cdot 4} = 0.443\left(\frac{kg\cdot m}{s}\right),\quad p_1 = 5\cdot 10^{-2}\cdot\sqrt{2\cdot 9.8\cdot 2} = 0.313\left(\frac{kg\cdot m}{s}\right),$$

$$\overline{F} = \frac{5\cdot 10^{-2}\cdot\sqrt{2\cdot 9.8}}{4\cdot 10^{-3}}\cdot\left(\sqrt{2} + \sqrt{4}\right) = 189\,(N).$$

Answer: $0.443\dfrac{kg\cdot m}{s}$, $0.313\dfrac{kg\cdot m}{s}$, $189\,N$.