Answer on Question 54936, Physics, Mechanics | Kinematics | Dynamics

Question:

A tennis ball is dropped from a height of $7m$ and rebounds to a height of $3m$. If it is in contact with the floor for $0.029s$, what is the average acceleration during this period?

Solution:

Let's first find the final velocity of the tennis ball when it hit the ground from the kinematic equation:

$$v^2 = v_0^2 + 2gy,$$

where, v_0 is the initial velocity of the tennis ball which is zero, v is the final velocity of the tennis ball when it hit the ground, g is the acceleration of gravity and y is the displacement.

Thus, the final velocity of the tennis ball when it hit the ground will be (since, we take the direction of the y-axis downward, the displacement of the tennis ball will be $y = 7m$, and $g = 9.8\frac{m}{s^2}$):

$$v = \sqrt{2gs} = \sqrt{2 \cdot 9.8\frac{m}{s^2} \cdot (7m)} = \sqrt{137.2\frac{m^2}{s^2}} = 11.71\frac{m}{s}.$$

Let's secondly find the initial velocity of the ball when it rebounds to a height of $3m$. We use the same kinematic equation as in the previous case. When the tennis ball reaches the height of $3m$ its final velocity will be zero, so we can rewrite our equation (in this case the displacement of the tennis ball will be $y = -3m$ and $g = -9.8\frac{m}{s^2}$):

$$0 = v_0^2 + 2gy,$$

$$0 = v_0^2 + 2 \cdot \left(-9.8\frac{m}{s^2}\right) \cdot (-3m),$$

$$v_0 = \sqrt{2 \cdot \left(-9.8\frac{m}{s^2}\right) \cdot (-3m)} = \sqrt{58.8\frac{m^2}{s^2}} = -7.67\frac{m}{s}.$$

The initial velocity of the ball have sign minus because we take the direction of the y-axis downward.

Finally, we can find the acceleration from the definition of the impulse:

$$F\Delta t = m\Delta v = mv - mv_0,$$

$$ma\Delta t = mv - mv_0,$$

$$a = \frac{v - v_0}{\Delta t} = \frac{11.71\,\frac{m}{s} - (-7.67\,\frac{m}{s})}{0.029s} = \frac{19.38\,\frac{m}{s}}{0.029s} = 668.3\,\frac{m}{s^2}.$$

Answer:

$a = 668.3\,\frac{m}{s^2}$.