Chapter 3 Problem 61 †

Given
$v_0 = 0.600\ m/s$
$v_f = 0\ m/s$
$\Delta x = 2.00\ mm = 2.00 \times 10^{-3}\ m$

Solution
a) Find the acceleration of the woodpecker's head.

Since change in velocity and position are provided, the fourth kinematic equation is useful for finding acceleration.

$$v_f^2 - v_0^2 = 2a\Delta x$$

Solving for acceleration gives

$$a = \frac{v_f^2 - v_0^2}{2\Delta x} = \frac{(0\ m/s)^2 - (0.600\ m/s)^2}{2(2.00 \times 10^{-3}\ m)} = -90.0\ m/s^2$$

This corresponds to

$$a = -90.0\ m/s^2 \left(\frac{1\ g}{9.80\ m/s^2}\right) = -9.18\ g's$$

b) Find the stopping time.

Since we now know the acceleration, we can calculate the stopping time with the first kinematic equation.

$$v_f = v_0 + at$$

Solving for t gives

$$t = \frac{v_f - v_0}{a} = \frac{0\ m/s - 0.600\ m/s}{-90.0\ m/s^2} = 6.67 \times 10^{-3}\ s$$

c) Since the tendons around the brain stretch during impact, what is the acceleration of the brain?

The stretch of tendons increases the stopping distance of the brain to 4.50 mm. Use this value in the equation from part a) and find the new acceleration is

$$a = \frac{v_f^2 - v_0^2}{2\Delta x} = \frac{(0\ m/s)^2 - (0.600\ m/s)^2}{2(4.50 \times 10^{-3}\ m)} = -40.0\ m/s^2$$

In g's this is

$$a = -40.0\ m/s^2 \left(\frac{1\ g}{9.80\ m/s^2}\right) = -4.08\ g's$$

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†Problem from University Physics by Ling, Sanny and Moebs (OpenStax)