109.

Problem 16.44E (HRW)

A (hypothetical) large slingshot is stretched 1.50 m *to launch a* 130 g *projectile with speed sufficient to escape from Earth* (11.2 km/s). *We can assume that the elastic sling shot obeys Hook's law. We have to find* (a) *the spring constant of the device, if all the elastic energy is converted to kinetic energy.* (b) *Assuming that an average person can exert a force of* 220 N, *we have to estimate the number of people required for stretching the slingshot.*

Solution:

(a)

The spring constant, k, of the device can be determined by requiring that the potential energy of the slingshot will be $\frac{1}{2}k\,a^2$, as the slingshot obeys Hook's law and a is the maximum stretch. As the potential energy of the slingshot is fully converted into kinetic energy of the projectile, we have the condition

$$\frac{1}{2}ka^2 = \frac{1}{2}mv^2,$$

where v is the speed with which the projectile of mass $m = 0.130 \text{ kg}$ is released from the stretched slingshot. As the projectile is released with the escape velocity of the Earth, $v = 11.2 \text{ km s}^{-1}$. We calculate the value of the spring constant

$$k = \frac{0.130 \times \left(11.2 \times 10^3\right)^2}{1.50^2} \text{ N m}^{-1} = 7.25 \times 10^6 \text{ N m}^{-1}.$$

Elastic force exerted on the slingshot in this situation is

$$F = 7.25 \times 10^6 \times 1.50 \text{ N} = 10.87 \times 10^6 \text{ N}.$$

(b)

It is given that an average person can exert a force of 220 N. Therefore, the number of persons needed to stretch the slingshot as per the data of the problem would be

$$N = \frac{10.87 \times 10^6}{220} = 49{,}432.$$