Answer on Question #73423 – Chemistry – General Chemistry

During a circus act, one performer swings upside down hanging from a trapeze holding another, also upside-down, performer by the legs. If the upward force on the lower performer is three times her weight, how much (in m) do the bones (the femurs) in her upper legs stretch? You may assume each is equivalent to a uniform rod 39.0 cm long and 1.90 cm in radius. Her mass is 57.5 kg.

Solution:

We are asked to find the extent of stretch of femur bones if a person who is upside down holds a person by his legs so that the second person is also upside down. The force applied by the first person on the others legs is 3 times the weight of the first person.

We will use the concept of elasticity in this question.

Mass of performer, M = 57.5 kg

Weight of the performer, W = Mg, g – acceleration due to gravity

$W = 57.5\ kg \times 9.8\ m/s^2 = 563.5\ N$

The force on the performer:

$F = 3 \times W = 3 \times 563.5 = 1690.5\ N$

Tensile force on one leg is half of the total force applied

$F_t = 0.5 \times 1690.5 = 845.25\ N$

Original length of the bones, l = 0.39 m

Radius of the bones, r = 0.019 m

Cross Sectional area of bones

$A = \pi r^2 = \pi(0.019)^2 m^2 = 1.13 \times 10^{-3}\ m^2$

Euler's equation can be used to calculate the elongation in the bones

$$\Delta l = \frac{1}{\gamma}\frac{F}{A}l$$

Δl is the elongation in the length, F is the force, A is the area of cross section and l is the initial length, γ is the Young's modulus (γ (bone tension) = $16 \times 10^9\ N/m^2$)

$$\Delta l = \frac{1}{16 \times 10^9}\frac{845.25}{1.13 \times 10^{-3}} \times 0.39 = 18 \times 10^{-6}\ m$$

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