INTERMEDIATE BONUS QUESTION

The critical buckling load of a beam can be found by the equation shown below where is the critical buckling force, is Young’s Modulus of Elasticity for the material of the beam, is the moment of inertia of the beam, and is the length of the beam.

As observed in the equation, the force applied is inversely related to the length of the beam, i.e., as the length of the beam increases, the critical load decreases by the square of that rate. The key principle discussed in the examples will be this relationship within the context of safety during exercise and time management.

The most apparent application of the inverse relationship is during the execution of the exercise machine by the name of leg press. During the execution of the exercise, the user positions his back on a seat and presses weight away from their, usually at a angle. At the point in which the leg muscles are fully stretched, the weight is often supported with legs fully extended and knees locked (fully extended such that the femur, tibia, and fibula are aligned), which can be potentially dangerous if performed incorrectly with large sums of weight.

The reason behind the danger is that, with sufficiently large loads, the force from supporting the weights at the extended position make cause too much strain on the knees and force them to bend. Ideally, the knees would bend as intended, bending along the knee joint. However, as has happened to multiple users when locking their legs, the weight may force the knee to bend in the opposite direction, destroying the tendons and ligaments in the leg, often leading to permanent damage.

With the danger established, the buckling law provides an interesting perspective on the relative safety of the user when extending their legs. As the equation suggests, users with longer legs often require a smaller critical load to force their knees to buckle, thus requiring extra caution when using the machine. By contrast, users with smaller legs have higher critical loads to force buckling, this making the movement relatively safer.

With that in mind, it is worth the difference in bone density and size also has a direct effect on the load required to affect the critical buckling force by affecting the modulus of elasticity. The example is meant to highlight the inverse relationship between the length and force required to buckle.