Let's talk about another contemporary challenge (which also is an old one): earthquakes.

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Figure 1: A simulation of the next Cascadia subduction zone earthquake.

In Oregon, earthquakes are quite relevant. The Cascadia subduction zone has had massive earthquakes about every 600 years for the last few millenia. The most recent was in 1700, and had a magnitude of 8.7-9.2, Geologists predict a 37% chance of a magnitude 8.2+ earthquake on the Cascadia subduction zone within the next 50 years. This will probably topple Weniger Hall, so students are advised to graduate promptly.

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Figure 2: P-waves. Illustration from USGS.

For P-waves in the ground, the shaking motion is in the direction in which the wave propagates. In this case the differential equation is

$$\frac{\partial^2 u}{\partial x^2} = \frac{\rho}{E}\frac{\partial^2 u}{\partial t^2} \tag{1}$$

where u is the displacement from equilibrium of the ground, ρ is the density of the earth's crust, and E is its Young's modulus, which quantifies how hard it is to compress the crust.

The speed of a P-wave is about 5 km/s. Estimate the Young's modulus of the crust. Give your answer in units of $\mathrm{N/m^2}$.