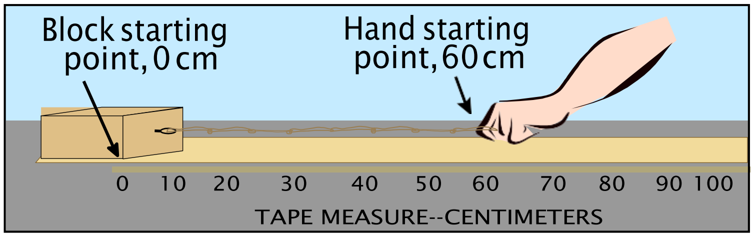
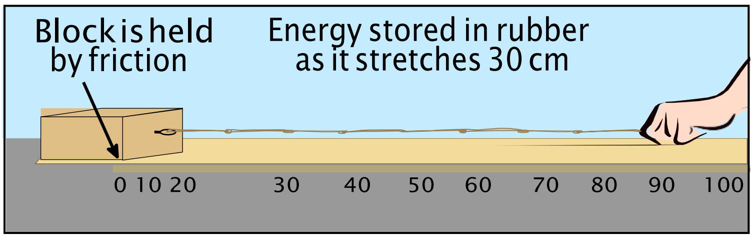
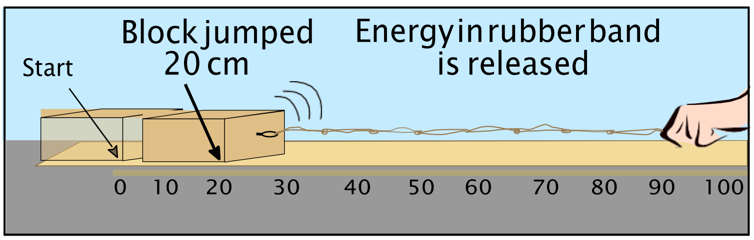
Earthquake Machine – Student Resource

How much energy will a fault store before it fails? Is this quantity constant for all faults?

How could pulling a block of wood with a string of rubber bands have anything to do with earthquakes? There are no rubber bands in the Earth, but all solids, including the Earth's crust, are elastic. Block & sandpaper model friction and elastic rebound (release) as an example of the interaction between tectonic plates before and after an earthquake.







Vocabulary

Fault: a break or fracture in Earth's crust along which movement has taken place.

Friction: mechanical resistance to the motion of objects or bodies that touch.

Stick-slip movement: a jerky, sliding movement along a surface. It occurs when friction between the two sides of a fault keeps them from sliding smoothly, so that stress is built up over time and then suddenly released.

Rupture along a fault typically occurs by *"Fits and starts,"* in a type of sporadic motion that geologists call stick-slip. As energy builds up, the rock on either side of the fault will store the energy until its force exceeds the strength of the fault. When the strength of the fault is overwhelmed, an earthquake will occur. Movement on the fault will continue until stress is relieved. In this manner, some of the energy stored in the rock, but not all of it, will be released by frictional heating on the fault, the crushing of rock, and the sending of earthquake waves.

Earthquakes and Elastic Rebound

The basic earthquake machine consists of a heavy object that is dragged steadily with an elastic cord or rubber band. Although pulled with a constant velocity, the heavy object repeatedly slides and sticks. This intermittent sliding motion mimics the intermittent fault slippage that characterizes the earthquake fault zones. In tectonically active regions, the plates, which are about 15-200 km thick, are slowly deformed elastically along active faults. As the deformation increases, stress also increases, until fault slippage releases the stored elastic energy. This process is called elastic rebound.

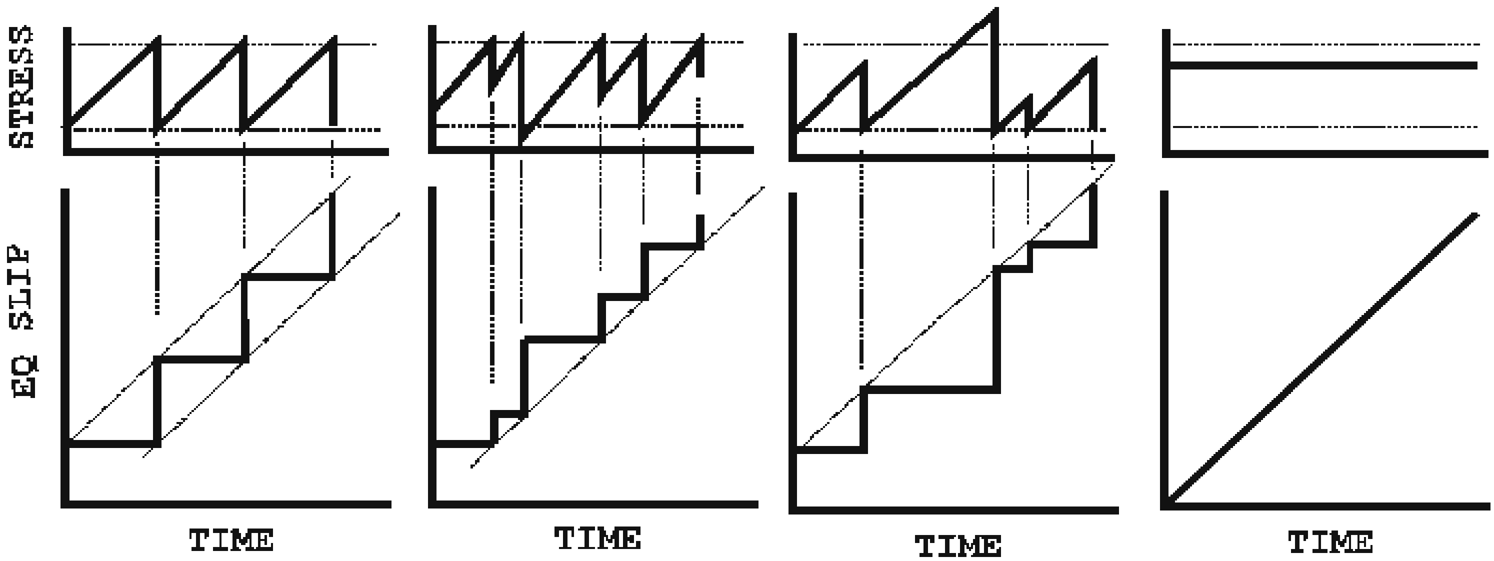
Stress and Friction*

Stress is force divided by the area of the fault (or wood block in this case). Since the area is constant, the length of the spring is also proportional to the stress applied to the fault. The frictional strength of the fault depends on the roughness of the sandpaper on the block and the board, on the area of the block, and on the force pushing the block against the board. This force is simply the weight of a rock (or any other weight) placed on top of the block. Note that there is a difference between static friction and dynamic friction. When at rest, the strength of the fault is determined by the static friction. However, as soon as the block starts moving, the strength (the stress which stops the motion) is determined by the dynamic friction. Static friction is always greater than dynamic friction; the friction is stronger when the block is at rest than when it is when moving. Finally, the displacement of the fault is simply the position of the block measured on the centimeter scale on the board. The slip during a particular "earthquake" is simply the difference in displacement before and after the earthquake.

[*From **Jeff Barker, Binghamton University**}

Earthquake hypotheses that can be explored with the model

These graphs illustrate four idealized models of earthquake recurrence for a fault that bounds two plates that are in steady motion with respect to each other.



Perfectly Periodic— In this model an earthquake always happens when the stress level reaches the same high value; and during the earthquake the stress always drops to the same low value. All of the earthquakes have the same slip, and they are equally spaced in time.	**Time Predictable**— In this model an earthquake always happens when the stress level reaches the same high value. The slip during each earthquake is variable, so the stress level after each earthquake is not always the same. Once the slip in one event has been measured, then it is known that the next event will happen when exactly this amount of plate motion has occurred.	**Slip Predictable**— In this model the stress always drops to the same level after an earthquake. Once an earthquake has occurred, then one knows that the slip during the next earthquake will be equal to the plate motion that has subsequently occurred. The longer the time since the last event, the larger the next event will be.	**Creeping**— There are fault segments that move by creep rather than by large earthquakes. This appears to be the case for the San Andreas fault where is passes through Hollister, California. The fault moves by a series of creep events, and each year the total slip from creep is the same as the amount of relative plate motion.