Energy Exchange and Equilibrium

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Definitions and Concepts:

- A body which is not moving is in a state of equilibrium.
- A body is in a state of stable equilibrium when any small movement increases its potential energy so that when released it tends to resume its original position.
- Translational kinetic energy is the energy due to motion of the center of mass of an object from one point to another.

Energy can be transferred from one object to another by doing work. When work is done on an object, it results in a change in the object's motion (more specifically, a change in the object's Kinetic energy)

One of the major principles of potential energy is the law of conservation of energy, which states that energy can neither be created nor destroyed. The energy expended to lift an object or compress a spring does not simply disappear; it is “stored” as potential energy. It is then released as kinetic energy by a restoring force. The energy input equals the energy output; there is no gain or loss in overall energy

Models:

Bending a Handsaw to Model the Energy Exchange in Catapult

Equipment used: A Handsaw
Bar of woods
$m_1 = 1.5$lbs
A bottle of coke of mass = m_2

Methods:

A bar of wood is sawed until the handsaw properly attached to it. The handsaw is bent by loading weights on to it until almost parallel to the horizontal and this deformation is measured as ' y_1' then a bottle of coke placed on to the saw and this new deformation caused by the bottle measured as y_2. Finally once the bottle is placed in an equilibrium position as shown in fig (b) the weights which keep the handsaw almost horizontally is removed as shown in fig (d) as a result the bottle of the cock is projected as shown in fig (e) and fig (f).

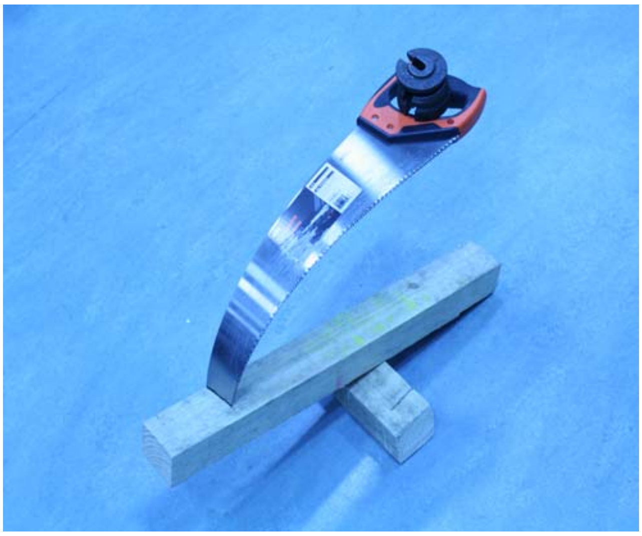


Fig (a)

Fig (b)

Fig (d)

Fig (c)

Fig (e)

Fig (f)

What is the principle behind this demonstration?

The principle is quite similar to elastic rubber bands of the slingshot which has each an unstretched length ‘L’ and a stiffness ‘k’. If they are pulled back to the position shown and released from rest, a pellet of mass ‘m’ will be fired vertically upward. Neglecting the mass of the rubber bands and the change in elevation of the pellet while it is constrained by the rubber bands it is possible to determine the speed of the pellet of mass ‘m’ just after the rubber bands become unstretched by applying the principle of conservation of energy.

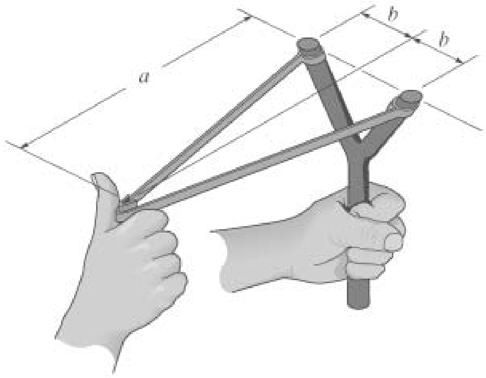
The sum energy just before released = The sum of energy just after released

(PE+ KE) before = (PE +KE) after

$$(2[\frac{1}{2}k(\sqrt{b^2+a^2}-1)^2]+0)=(0+\frac{1}{2}mv^2)$$

$$v=\sqrt{\frac{2k}{m}}\left(\sqrt{b^2+a^2}-1\right)$$

Fig (5)



Analysis of the handsaw models:

Similarly, the handsaw model demonstrated above can be analyses by using the same principle as the rubber band

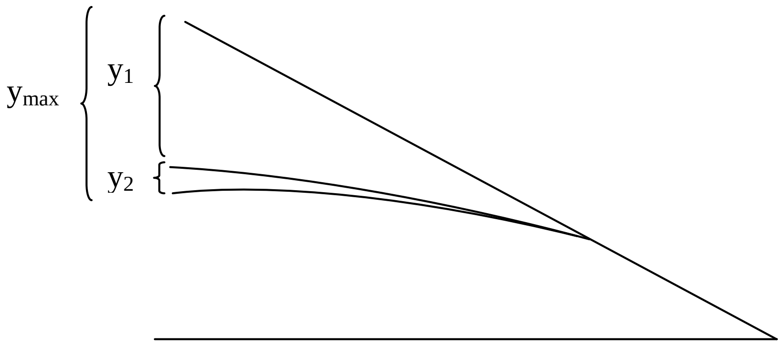


Fig (6)

Free body diagram of the handsaw

Where y_1 is the deformation caused by a mass m_1 = 1.5lbs mass and y_2 the deformation caused by the bottle of mass m_2

The sum energy just before the weight removed = The sum of energy just after the weight removed

(PE+ KE) before = (PE +KE) after

$$(m_1 g y_1 + m_2 g y_2 + 0) = (0 + \frac{1}{2} m_2 v_2{}^2)$$

$$2g(m_1 y_1 + m_2 y_2) = m_2 v_2{}^2$$

$$v_2 = \sqrt{\frac{2g}{m_2}(m_1 y_1 + m_2 y_2)}$$

Reference:

http://www.mace.manchester.ac.uk/project/teaching/civil/structuralconcepts/

http://www.google.co.uk/images?hl=en&q=catapul%5D&um=1&ie=UTF-8&source=og&sa=N&tab=wi