Energy & work

Definition of Work:

In physics, a force is said to do work if, when acting on a body, there is a displacement of the point of application in the direction of the force.

Units:

The SI unit of work is the joule (J)

N . m = J

1 lb . ft = 1.356 J

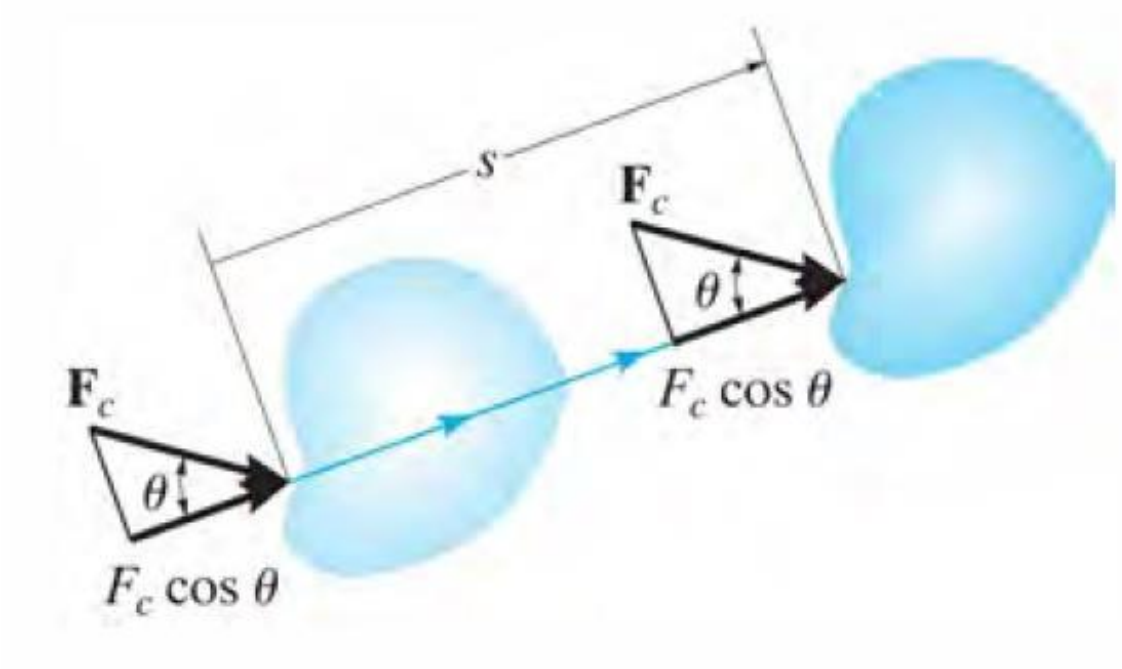
The work **U** done by a constant force of magnitude **F** on a point that moves a displacement **S** is:

$$U = F . S$$

Work of Constant Force:

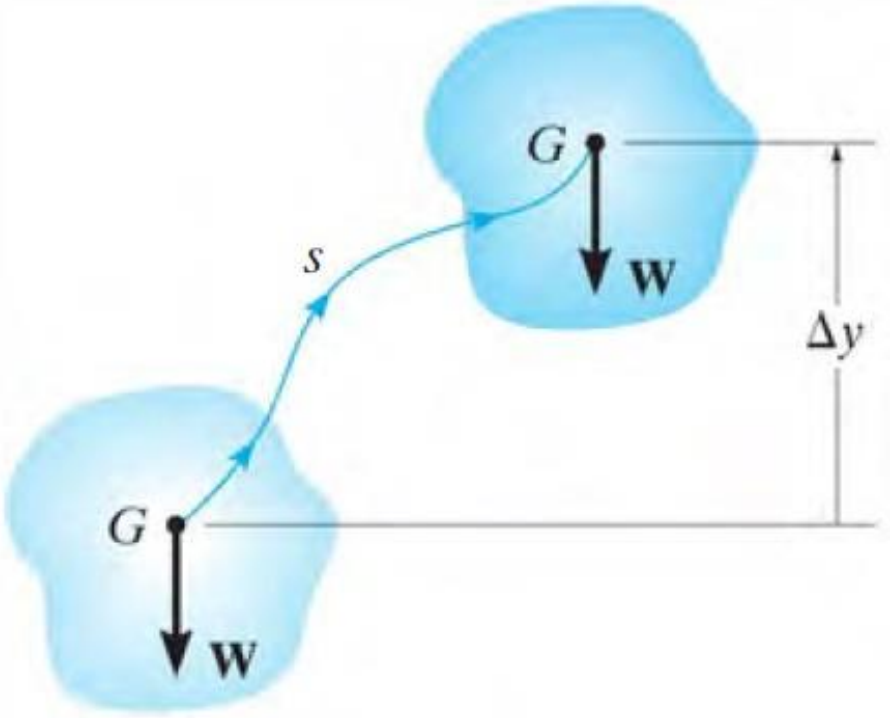
The constant force F_c that acts on the body, which produces a displacement S, can be explained as work equation:

$$\mathbf{U = (F \cos \Theta) S}$$



Work of a Weight:

$$\mathbf{U = W \cdot \Delta y}$$

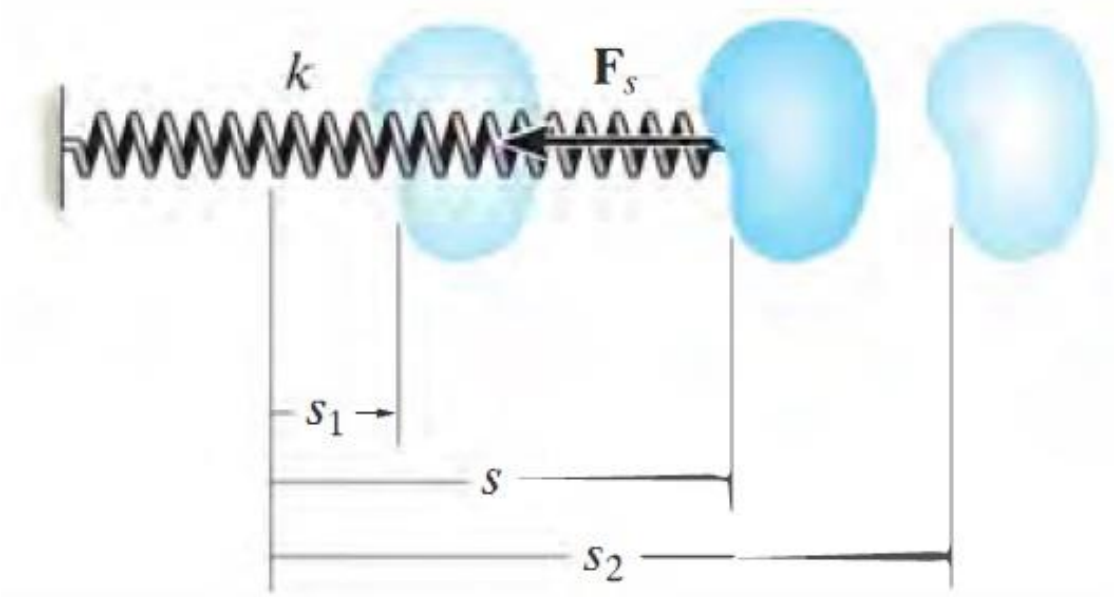


Work of a Spring Force:

The spring force is F = - K . S

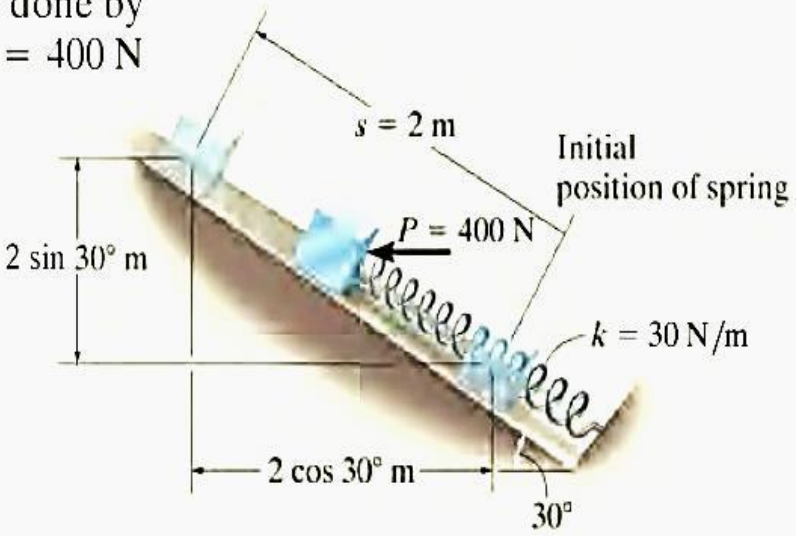
$$U = -\frac{1}{2}(K S_2^2 - K S_1^2)$$

$$U = -\frac{1}{2}(F_2 - F_1)\Delta s$$



EXAMPLE

The 10-kg block rests on the smooth incline. If the spring is originally stretched 0.5 m, determine the total work done by all the forces acting on the block when a horizontal force $P = 400$ N pushes the block up the plane $s = 2$ m.



SOLUTION

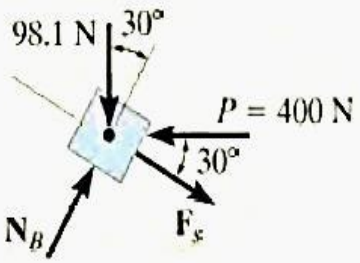
Horizontal Force *P*.

Since this force is *constant*, the work is

$$U_P = 400\,(2\cos 30°) = 692.8\,\text{J}$$

or

$$U_P = 400\,\text{N}\cos 30°(2\,\text{m}) = 692.8\,\text{J}$$



Spring Force F_s.

$s_1 = 0.5\ \text{m}$

$s_2 = 0.5\ \text{m} + 2\ \text{m} = 2.5\ \text{m}$

$$U_s = -\left[\tfrac{1}{2}(30\ \text{N/m})(2.5\ \text{m})^2 - \tfrac{1}{2}(30\ \text{N/m})(0.5\ \text{m})^2\right] = -90\ \text{J}$$

Weight W.

$$U_W = -(98.1\ \text{N})\ (2\ \text{m} \sin 30°) = -98.1\ \text{J}$$

Total Work.

$$U_T = 692.8\ \text{J} - 90\ \text{J} - 98.1\ \text{J} = 505\ \text{J} \qquad \textit{Ans.}$$

Kinetic Energy of a Particle, Principle of Work and Energy

Kinetic energy is defined in expression of

$$\boldsymbol{T = \frac{1}{2}\, mv^2}$$

Unit

$$Kg.\left(\frac{m}{s}\right)^2 = \frac{Kg\,.m}{s^2}\ .\ m = N\,.m = J$$

OR = lb . ft

Then the work and energy of a particle moves from point 1 to point 2 can be express by the equation:

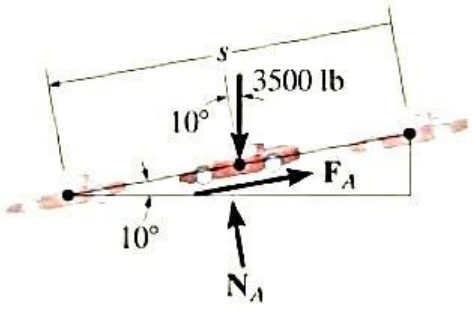
$$\mathbf{U = T_2 - T_1}$$

The work and energy also can be written as

$$\mathbf{T_1 + \sum U = T_2}$$

EXAMPLE

The 3500-lb automobile travels down the 10° inclined road at a speed of 20 ft/s. If the driver jams on the brakes, causing his wheels to lock, determine how far s the tires skid on the road. The coefficient of kinetic friction between the wheels and the road is $\mu_k = 0.5$.



SOLUTION

Work

$$+\nwarrow \Sigma F_n = 0; \quad N_A - 3500 \cos 10^\circ \text{ lb} = 0 \qquad N_A = 3446.8 \text{ lb}$$

Thus,

$$F_A = \mu_k N_A = 0.5\,(3446.8 \text{ lb}) = 1723.4 \text{ lb}$$

Principle of Work and Energy.

$$T_1 + \Sigma U_{1\text{-}2} = T_2$$

$$\frac{1}{2}\left(\frac{3500 \text{ lb}}{32.2 \text{ ft/s}^2}\right)(20 \text{ ft/s})^2 + 3500 \text{ lb}(s \sin 10^\circ) - (1723.4 \text{ lb})s = 0$$

Solving for s yields

$$s = 19.5 \text{ ft} \qquad \textit{Ans.}$$

H. W. : Chapter 14: 1, 6, 7, 8, 10