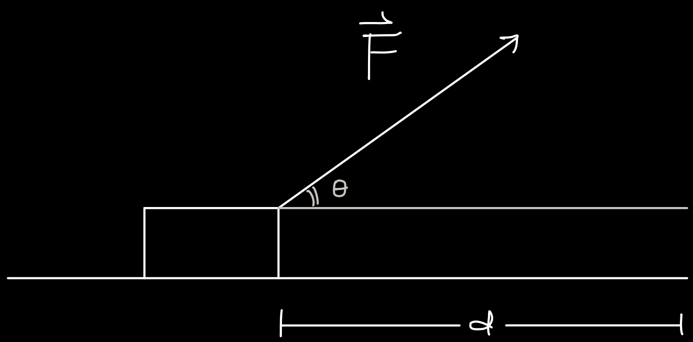


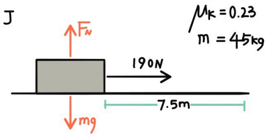
$$W = |\vec{F}||d|\cos\theta$$
$$= \boxed{F d \cos\theta}$$
$$[W] = Nm$$

Kinetic Energy

$$KE = \frac{1}{2}mv^2 \quad [J]$$
$$W_{net} = \Delta KE$$

6.10 A 45-kg box is being pushed a distance of 7.5 m across the floor by a force $\vec{P}$ of magnitude is 190 N. The force $\vec{P}$ is parallel to the displacement of the box. The coefficient of kinetic friction between the box and the floor is 0.23. Determine the work done on the box by each of the *four* forces that act on the box. Be sure to include the proper plus or minus sign for the work done by each force.

a) $W_P = 190N * 7.5m * \cos(0) = 1.4 * 10^3 J$
$W_f = f_k * d * \cos(180°) = -760J$
$W_N = F_N * d * \cos(90°) = 0J$
$W_g = 0J$



$\mu_k = 0.23$
$m = 45kg$

$$F_{net} = 89 N \hat{x}$$
$$\begin{aligned} W_{net} &= F_{net} * d\cos(0°) = ma * d * 1 \\ &= ma * \Delta x \\ &= m * \left(\frac{V^2}{2} - \frac{V_0^2}{2}\right) \\ &= \boxed{\Delta\left(\frac{1}{2}mv^2\right)} \end{aligned}$$

Conservative and Nonconservative Forces

1. A force is called "conservative" if the work that it does can convert kinetic energy into potential energy and vice versa so that the *total* mechanical energy remains constant.
Examples of conservative forces: the gravitational force, the spring (elastic) force, the electrostatic force.

2. Potential energy can be defined for *any* conservative force, F_c.
Examples: gravitational potential energy $PE_g = mgh$, spring potential energy $PE_s = ½kx^2$, etc.

3. Conservative forces *acting alone* always lower potential energy. In general, the work done by conservative forces equals the decrease in the associated potential energy:
$W_g = -\Delta PE_g$, $W_s = -\Delta PE_s$. In general, $W_c = -\Delta PE_c$.

4. A force is called nonconservative if the work it does can change the total mechanical energy.
Examples of nonconservative forces: kinetic friction, applied forces, tension, air resistance.

5. Potential energy functions cannot be defined for nonconservative forces.

$$PE = mgh$$
$$W_g = -\Delta PE_g$$

$$W_c = -\Delta PE_{conservative}$$

The Conservation of Mechanical Energy

1. Total mechanical energy = $E = KE + PE$

2. **<u>The Principle of Conservation of Mechanical Energy</u>**: When no nonconservative forces do work, the *total* mechanical energy, E, does *not* change: $\Delta E = \Delta(KE + PE) = \Delta KE + \Delta PE = 0$. Under these circumstances we can relate the total kinetic energy ***plus*** total potential energy at instant (1) to that at another instant (2) without considering the intermediate motions and *without finding the work done by the forces* involved:

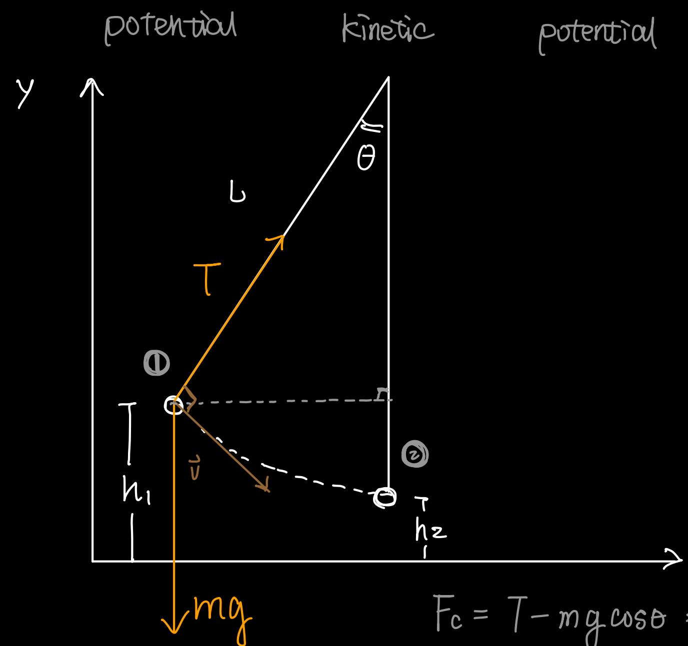
$$KE_1 + PE_1 = KE_2 + PE_2$$

3. **The Generalized Work-Energy Theorem**: The work done by the nonconservative forces is equal to the change in the total mechanical energy: $W_{nc} = \Delta E = E_f - E_0$. Like the original Work-Energy Theorem, this theorem is *always* valid. However, it is often useful to begin analyzing problems with the *generalized* work-energy theorem, in case there are non-conservative forces that do work.

Work/Energy Example

A simple pendulum consists of a small object of mass $m = 0.150$ kg suspended from a support stand by a light string. The string has a length $L = 0.750$ m. The string has an initial position given by $\theta = 65.0°$ relative to the vertical. The pendulum is released from rest. Air resistance is negligible during the subsequent motion of the pendulum.

a) Calculate the work done by gravity on the pendulum as it moves from its initial position to the lowest point of its semicircular arc.
b) Calculate the speed of the object as it moves through the lowest point of its semicircular arc.
c) Calculate the tension in the string right as the object is moving through the lowest point of its semicircular arc.
d) Repeat part b) using the conservation of total mechanical energy. (Is the total mechanical energy of the pendulum conserved?)



$F_c = T - mg\cos\theta = 0$

perpendicular to displacement

<a> $W_g = -\Delta \underbrace{PE_g}_{mgh}$

$= mgl(1-\cos\theta)$ Δ eliminated the distance to the ground

$= 0.637\ J$

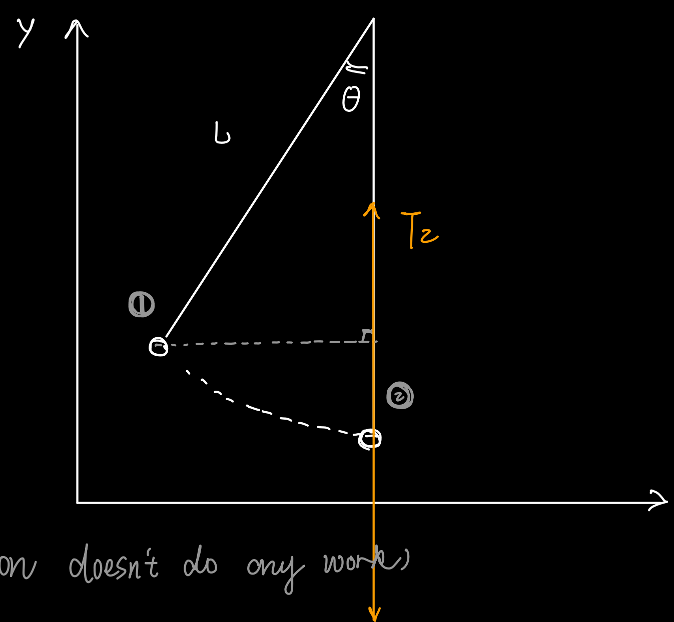
<b> $W_{net} = \Delta KE = \frac{1}{2}m(v^2 - v_0^2)$

$W_{net} = W_T + W_g$

$W_T = Td\cos\theta$ $\vec{v} \parallel \vec{d}$ always 0

$W_{net} = W_g = \frac{1}{2}mv^2$

$v = \sqrt{\frac{2W_{net}}{m}} = 2.91\ m/s$



<c> $\Sigma F_y = ma_y = T_2 - mg$

$T_2 = ma_y + mg$

$= m(\frac{v^2}{L} + g) = 3.17N$

<d> $W_{nc} = 0 \Rightarrow E_1 = E_2$ (Tension doesn't do any work)

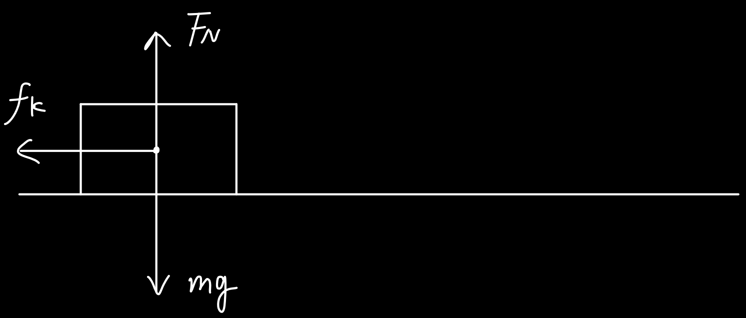
$\frac{1}{2}mv_1^2 + mgh_1 = \frac{1}{2}mv_2^2 + mgh_2$

$v_2 = \sqrt{2g\underbrace{(h_1 - h_2)}_{L(1-\cos\theta)}}$

$= 2.91\ m/s$

$d = 24.5$

$\mu_k =$



Conservation Principles

1. ***The Principle of Conservation of Total Mechanical Energy***:
   If the total work done on a system by *nonconservative* forces is zero, then the total mechanical energy of the system remains constant.

2. ***The Principle of Conservation of Total Linear Momentum:***
   If the total work done on a system by *external* forces (conservative and/or nonconservative) is zero, then the total linear momentum of the system remains constant.

$$P_{avg} = F V_{avg}$$

$$P_{avg} = \frac{W}{t}$$

$$W = \frac{\Delta PE}{t}$$