Chapter 9 Discussion
Work and Kinetic Energy

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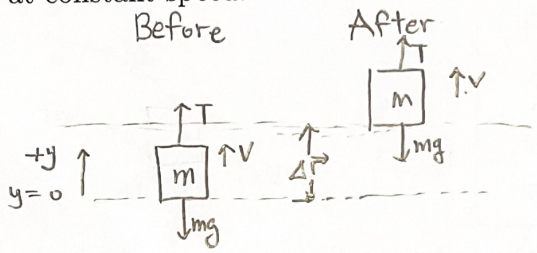
1. For each situation below:

   - Draw a Before/After diagram.
   - Draw and label the displacement vector $\Delta\vec{r}$.
   - Draw a free-body diagram.
   - Fill in the table by showing the sign (+, −, or 0) of the quantities listed (the subscripts on W indicate work done by that particular force).

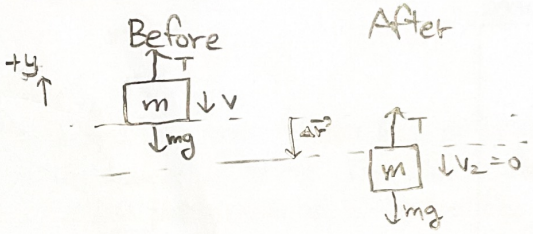
(a) An elevator moves up at constant speed.

W_T	+
W_G	−
$\sum W$	0
ΔK	0



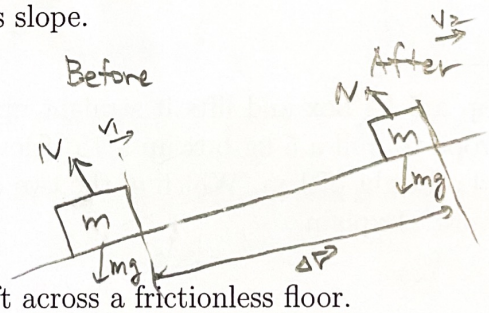
(b) A descending elevator brakes to a halt.

W_T	−
W_G	+
$\sum W$	−
ΔK	−



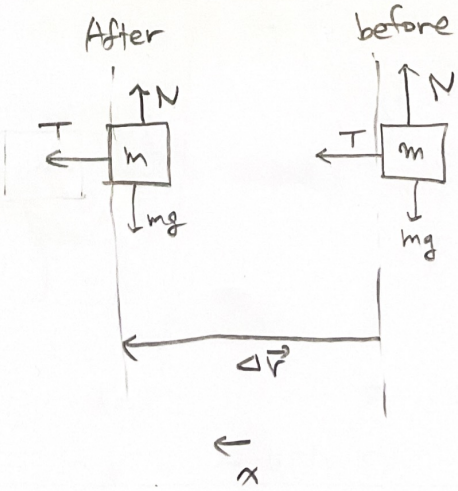
(c) A box slides up a frictionless slope.

W_N	0
W_G	−
$\sum W$	−
ΔK	−



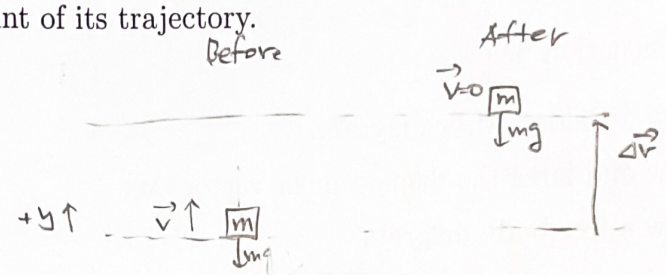
(d) A rope pulls a box to the left across a frictionless floor.

W_T	+
W_N	0
W_G	0
$\sum W$	+
ΔK	+



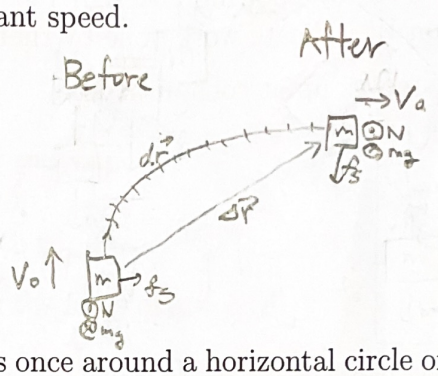
(e) A ball is thrown straight up. Consider the ball from just after it leaves your hand until the highest point of its trajectory.

W_{hand}	0
W_G	—
$\sum W$	—
ΔK	—



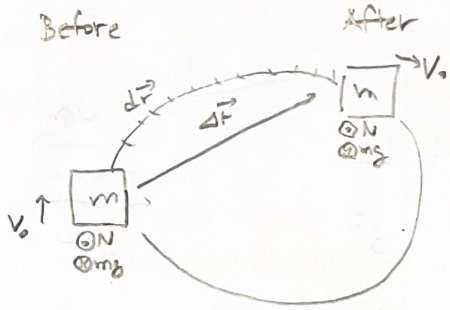
(f) A car turns a corner at constant speed.

W_{f_s}	0
W_N	0
W_G	0
$\sum W$	0
ΔK	0



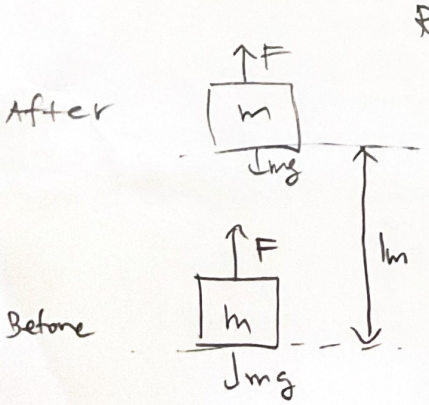
(g) A flat block on a string swings once around a horizontal circle on a frictionless table at steady speed.

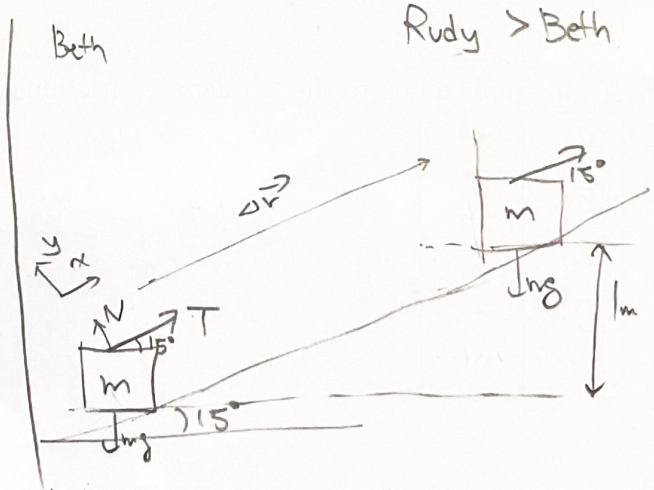
W_T	0
W_N	0
W_G	0
$\sum W$	0
ΔK	0



2. Rudy picks up a 5 kg box and lifts it straight up, at constant speed, a height of 1 m. Beth uses a rope to pull a 5 kg box up a 15° frictionless slope, at constant speed, until it has reached a height of 1 m. Which of the two does more work? Or do they do equal amounts of work? Explain.

Rudy > Beth





$\sin 15° = \frac{1}{\Delta r}$

$\Delta r = 3.837$

$\sum W_T = 12.6821 \times 3.837 = 48.66J$

$\sum F_y = F - mg = ma_y = 0$

$F = mg = 5 \times 9.8 = 49N$

$\sum W_F = 49N \times 1m = 49J$

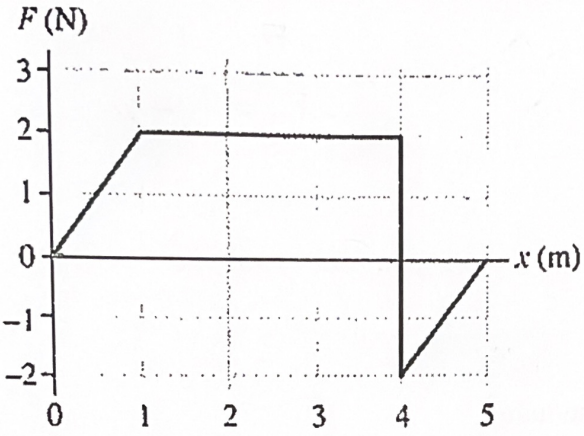
$\sum F_y = N - mg\cos\theta = ma_y = 0$

$\sum F_x = T - mg\sin\theta = ma_x = 0$

$T = mg\sin\theta$

$= 12.6821N$

3. A 1 kg particle moving along the x-axis experiences the force shown in the graph. If the particle's speed is 2 m/s at $x = 0$ m, what is its speed when it gets to $x = 5$ m?



$W = \int_0^5 F_x \, dx$

$= 6J$

$\boxed{V_5 = 4 m/s}$

$\Sigma W = K_5 - K_0$

$= \frac{1}{2} m v_5^2 - \frac{1}{2} m v_0^2$

$\frac{1}{2} m v_5^2 - 2 = 6$

$v_5^2 = 16$

4. The left end of a spring is attached to a wall. When Bob pulls on the right end with a force of 200 N, he stretches the spring by 20 cm. The same spring is then used for a tug-of-war between Bob and Carlos. Each pulls on his end of the spring with a 200 N force.

(a) What is the spring constant for this spring?

$F = kx$, $200N = K(0.2m)$

$K = 1000$

(b) How much work did Bob do on the spring when it was attached to the wall?

$W_p = \frac{1}{2} k x^2 = \frac{1}{2}(-1000)(0.04m^2) = \boxed{20J}$

(c) How far does Bob's end of the spring move in the tug-of-war? Explain.

$F = K(x + x_2)$, $\frac{F}{K} = (x + x_2) = 20cm$

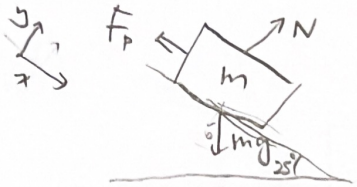
Bob Pulls $\boxed{10cm}$

(d) How far does Carlos's end of the spring move in the tug-of-war? Explain.

explanation above.

Carlos pulls $\boxed{10cm}$

5. A 380 kg piano slides 2.9 m down a 25° incline and is kept from accelerating by a man who is pushing back on it parallel to the incline (ignore friction). Determine:



$\Sigma F_x = mg\sin 25° - F_p = ma_x = 0$

$\Sigma F_y = N - mg\cos 25° = ma_y = 0$

(a) the force exerted by the man

$F_p = mg\sin 25° = 1574N$

(b) the work done on the piano by the man

$W_p = 1574N \times 2.9m \times \cos 180° = -4564J$

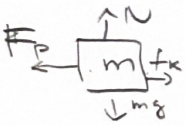
(c) the work done on the piano by the force of gravity

$W_g = mg\sin 25° \times 2.9 = 4564J$

(d) the net work done on the piano.

$\Sigma W = 0$

6. You push with a force of 400 N and use 200 W of power to push a box across a rough floor at steady speed.



$F_p = f_k$

$400N = f_k$

(a) How much force is needed to push the box twice as fast? Explain. $\boxed{1600N}$

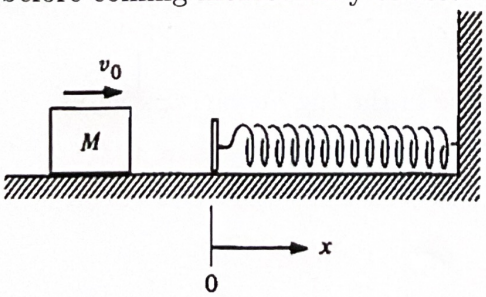
$\Sigma W = \Delta K = F \cdot d$ $\quad \frac{1}{2}mv^2$ when twice the speed force should 4 times

(b) How much power would you need to exert to push the box twice as fast? Explain.

~~400~~ $\Sigma W = F \cdot d$ $\quad d = 0.5m$

$200 = 400N \cdot d$ $\quad 1600N \cdot 0.5m = 800J$ $\boxed{800J}$

7. A block of mass M slides along a frictionless horizontal table with speed v_0. At $x = 0$ it hits a spring with spring constant k. Find the amount of work done by the elastic force on the block as it slides to a distance $x = d$. To what distance d will the block reach before coming momentarily to rest?



$F_p \leftarrow \boxed{m}$

$\Sigma W = \frac{1}{2}m\cancel{v_f^2}^{\,0} - \frac{1}{2}mv_0^2$

$F \cdot d = -kxd = -\frac{1}{2}mv_0^2$

$\boxed{d = \frac{mv_0^2}{2kx}}$ $\quad \boxed{W = kxd = \frac{1}{2}mv_0^2}$