## Chapter 10 Discussion
## Interactions and Potential Energy

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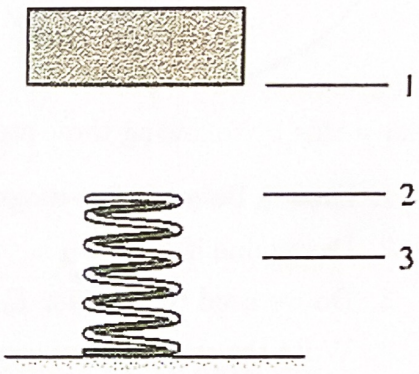
1. A heavy object is released from rest at position 1 above a spring. It falls and contacts the spring at position 2. The spring achieves maximum compression at position 3. Fill in the table below to indicate whether each of the quantities are +, −, or 0 during the three intervals.

| | $1 \to 2$ | $2 \to 3$ | $1 \to 3$ |
|---|---|---|---|
| $\Delta K$ | + | − | 0 |
| $\Delta U_G$ | − | − | − |
| $\Delta U_{sp}$ | 0 | + | + |




2. A spring gun shoots out a plastic ball at speed $v_0$. The spring is then compressed twice the distance it was on the first shot.

   (a) By what factor is the spring's potential energy increased?

   $U_{sp} = \frac{1}{2}kx^2$

   $U_{sp_1} = \frac{1}{2}k(x_1)^2$

   $x \to 2x$

   $U \to \frac{1}{2}k(2x)^2 = 4(\frac{1}{2}kx^2) = 4U$

   4

   (b) By what factor is the ball's launch speed increased?

   $\frac{1}{2}mv^2 = \frac{1}{2}kx^2$

   $mv^2 = kx^2$

   $\Delta E_{mech} = W_{nc}$

   $\therefore 2$

3. Give a specific example of a situation in which

   (a) $W_{ext} \to K$ with $\Delta U = 0$ and $\Delta E_{th} = 0$.

   A girl on a skate board moving horizontally. (No friction, No Drag)

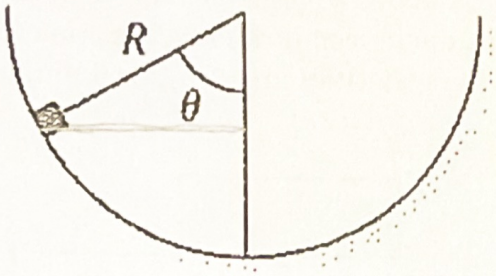
   (b) $W_{ext} \to U$ with $\Delta K = 0$ and $\Delta E_{th} = 0$.

   Lifting something with constant speed. (Sling shot)

   (c) $W_{ext} \to E_{th}$ with $\Delta K = 0$ and $\Delta U = 0$.

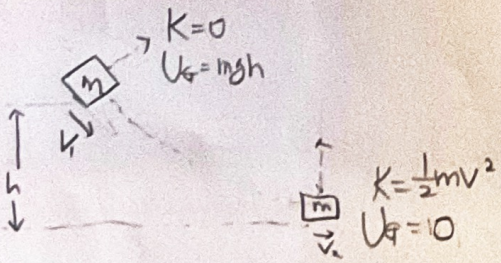
   constant speed, horizontally pushing or pulling

4. A small cube of mass $m$ slides back and forth in a frictionless, hemispherical bowl of radius $R$. Suppose the cube is released at angle $\theta$. What is the cube's speed at the bottom of the bowl?




Solve this by following these steps:

1. Draw a Before/After diagram, labelling speeds and positions.
2. Determine if $K$ or $U_G$ is zero in the initial and final states.
3. Do we need to consider $E_{th}$? Why or why not? nonconservative
4. Write the statement of conservation of energy (in terms of variables), and drop any terms that are zero. Gravitational,
5. You're given an initial angle, not position. Use geometry/trigonometry to find the initial height in terms of $R$ and $\theta$. $R - R\cos\theta$
6. Solve for $v$. $\sqrt{2g(R-R\cos\theta)}$

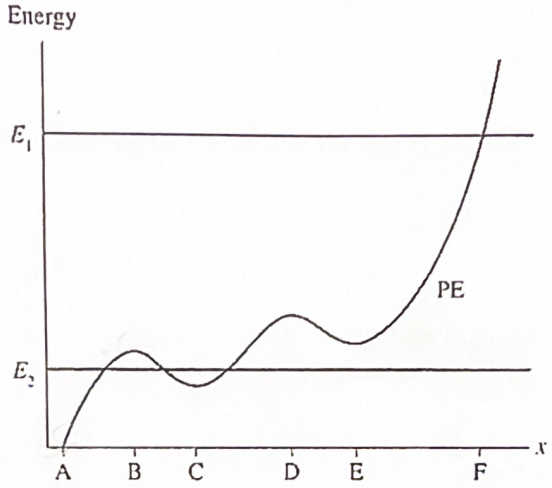



$$0 + mgh = \frac{1}{2}mv^2 + 0$$

$$gh = \frac{1}{2}v^2$$

$$\sqrt{2gh} = v \qquad (h = R - R\cos\theta)$$

5. The figure shows a potential energy curve. Suppose a particle with total energy $E_1$ is at position A and moving to the right.




(a) For each of the following regions of the $x$-axis, does the particle speed up, slow down, maintain a steady speed, or change direction?

| | |
|---|---|
| A to B | − |
| B to C | + |
| C to D | − |
| D to E | + |
| E to F | − |

(b) Where is the particle's turning point? F

(c) For a particle that has total energy $E_2$, what are the possible motions and where do they occur along the $x$-axis?

Point A to where PE and $E_2$ crosses.

(d) What position or positions are points of stable equilibrium? For each, would a particle in equilibrium at that point have total energy $E \leq E_2$, $E_2 < E < E_1$, or $E \geq E_1$?

C, E

C ( $E \leq E_2$ )

E ( $E_2 < E < E_1$ )

(e) What position or positions are points of unstable equilibrium? For each, would a particle in equilibrium at that point have total energy $E \leq E_2$, $E_2 < E < E_1$, or $E \geq E_1$?

B, D

B ( $E_2 < E < E_1$ )

D ( $E_2 < E < E_1$ )

Initial ①

Final ②

2.0

6. You drop a 5 g ball from a height of 2.0 m, and it bounces back to a height of 1.6 m.

   (a) What fraction of its initial energy is lost during the bounce?

$$\frac{E_{lost}}{E_{initial}} = \frac{mgh_1 - mgh_2}{mgh_1} = \frac{h_1 - h_2}{h_1} = \frac{(2.0)-(1.6)}{(2.0)} = 0.2$$

0.2

   (b) What is the ball's speed just before and just after the bounce?

$\frac{1}{2}mv^2 = mg(2.0)$

$v = \sqrt{2g(2.0)} = 6.261\,m/s$

right after $= mg(1.6)$

$\frac{1}{2}mv^2 = mg(1.6)$

$v = \sqrt{2g(1.6)} = 5.6\,m/s$

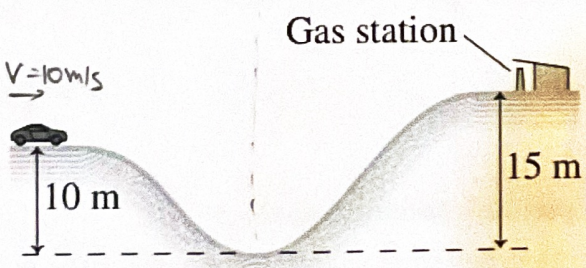
Just before: 6.261 m/s

Just after: 5.6 m/s

   (c) How much mechanical energy is "lost"? Where did the energy go?

7. A 1500 kg car traveling at 10 m/s suddenly runs out of gas while approaching the valley shown below. The alert driver immediately puts the car in neutral so that it will roll. What will be the car's speed as it coasts into the gas station on the other side of the valley?

1.4142 m/s




$$\cancel{m}gh + \frac{1}{2}\cancel{m}v^2 = \cancel{m}gh + \frac{1}{2}\cancel{m}v^2$$

$$gh + \frac{1}{2}v^2 = gh + \frac{1}{2}v^2$$

$$(9.8)(10m) + \frac{1}{2}(10^2) = (9.8)(15m) + \frac{1}{2}v^2$$

$$148 = 147 + \frac{1}{2}v^2$$

$$1 = \frac{1}{2}v^2$$

$$2 = v^2$$

$$\sqrt{2} = v \approx \boxed{1.4142\,m/s}$$