1. a) The crane is doing work on the piano. The piano's gravitational potential energy increases while the crane's energy decreases.

   b) The truck is doing work on the tires and on the asphalt. The tires' and the asphalt's internal energy increases while the truck's energy decreases.

   c) Margaret is doing work on the spring. The spring's elastic potential energy increases while Margaret's energy decreases.

   d) The spring is doing work on the dart. The dart's kinetic energy increases while the spring's energy decreases.

   e) Francis is doing work on the weights of the cuckoo clock. The weights' gravitational potential energy increases while Francis' energy decreases.

   f) Amy is doing work on the mainspring. The mainspring's elastic potential energy increases while Amy's energy decreases.

   g) The spring is doing work on the toy car. The toy car's kinetic energy increases while the spring's energy decreases.

   h) The toy car is doing work on the wall and on itself. The toy car's and wall's internal energy increases while the toy car's (mechanical) energy decreases.

2. a) gravitational potential energy

   b) $E_p = m \cdot g \cdot h = 58.0\ \text{kg} \cdot 9.81\ \frac{\text{m}}{\text{s}^2} \cdot 15.0\ \text{m} = 8'535\ \text{J} = \underline{\underline{8.53\ \text{kJ}}}$

3. a) elastic potential energy

   b) $E_p = \frac{1}{2} \cdot k \cdot y^2 = \frac{1}{2} \cdot 500\ \frac{\text{N}}{\text{m}} \cdot 0.0100^2\ \text{m}^2 = \underline{\underline{0.025\ \text{J}}} = \underline{\underline{25\ \text{mJ}}}$

   or: $E_p = \frac{1}{2} \cdot k \cdot y^2 = \frac{1}{2} \cdot 5.0\ \frac{\text{N}}{\text{cm}} \cdot 1.00^2\ \text{cm}^2 = 2.5\ \text{N}\cdot\text{cm} = 0.025\ \text{N}\cdot\text{m} = \underline{\underline{0.025\ \text{J}}} = \underline{\underline{25\ \text{mJ}}}$

4. a) kinetic energy

   b) $E_k = \frac{1}{2} \cdot m \cdot v^2 = \frac{1}{2} \cdot 453'000\ \text{kg} \cdot \left(\frac{199}{3.6}\ \frac{\text{m}}{\text{s}}\right)^2 = 692'100'810\ \text{J} = \underline{\underline{6.92 \cdot 10^8\ \text{J}}} = \underline{\underline{0.692\ \text{GJ}}}$

5. $E_p = m \cdot g \cdot h = 77'000\ \text{kg} \cdot 9.81\ \frac{\text{m}}{\text{s}^2} \cdot 11'900\ \text{m} = 8'988'903'000\ \text{J} = 8.989\ \text{GJ}$

   $E_k = \frac{1}{2} \cdot m \cdot v^2 = \frac{1}{2} \cdot 77'000\ \text{kg} \cdot \left(\frac{885}{3.6}\ \frac{\text{m}}{\text{s}}\right)^2 = 2'326'710'069\ \text{J} = 2.327\ \text{GJ}$

   $E_{total} = E_p + E_k = 8.989\ \text{GJ} + 2.327\ \text{GJ} = \underline{\underline{11.3\ \text{GJ}}}$

6. A: $E_p = m \cdot g \cdot h = 0.100\ \text{kg} \cdot 9.81\ \frac{\text{m}}{\text{s}^2} \cdot 4.2\ \text{m} = \underline{\underline{4.1\ \text{J}}}$

B: $E_p = m \cdot g \cdot h = 0.100\ \text{kg} \cdot 9.81\ \frac{\text{m}}{\text{s}^2} \cdot 1.2\ \text{m} = \underline{\underline{1.2\ \text{J}}}$

C: $E_p = m \cdot g \cdot h = 0.100\ \text{kg} \cdot 9.81\ \frac{\text{m}}{\text{s}^2} \cdot 0 = \underline{\underline{0}}$

7. a) $E_{p(\text{elastic})} = \frac{1}{2} \cdot k \cdot y^2 = \frac{1}{2} \cdot 200\ \frac{\text{N}}{\text{m}} \cdot 0.050^2\ \text{m}^2 = \underline{\underline{0.25\ \text{J}}}$

b) $E_{p(\text{elastic})} = E_{p(\text{gravitational})}$ $\quad h = \frac{E_{p(\text{gravitational})}}{m \cdot g} = \frac{0.25\ \text{J}}{0.040\ \text{kg} \cdot 9.81\ \frac{\text{m}}{\text{s}^2}} = 0.637\ \text{m} = \underline{\underline{64\ \text{cm}}}$

c) $E_{p(\text{elastic})} = E_{p(\text{gravitational})} = E_k$ $\quad v = \sqrt{\frac{2 \cdot E_k}{m}} = \sqrt{\frac{2 \cdot 0.25\ \text{J}}{0.040\ \text{kg}}} = \underline{\underline{3.5\ \frac{\text{m}}{\text{s}}}}$

8. $E_p = m \cdot g \cdot h = 88.0\ \text{kg} \cdot 9.81\ \frac{\text{m}}{\text{s}^2} \cdot 384\ \text{m} = 331\ \text{kJ}$

Chocolate: contains 21.8 kJ per g, therefore he eats $\frac{331\ \text{kJ}}{21.8\ \frac{\text{kJ}}{\text{g}}} = \underline{\underline{15.2\ \text{g}}}$ of chocolate.

9. a) $E_p = m \cdot g \cdot h = 2.00\ \text{kg} \cdot 9.81\ \frac{\text{m}}{\text{s}^2} \cdot 20.0\ \text{m} = \underline{\underline{392\ \text{J}}}$

b) $E_p = E_k$ $\quad v = \sqrt{\frac{2 \cdot E_k}{m}} = \sqrt{\frac{2 \cdot 392\ \text{J}}{2.00\ \text{kg}}} = \underline{\underline{19.8\ \frac{\text{m}}{\text{s}}}}$

c) $E_p = m \cdot g \cdot h = 4.00\ \text{kg} \cdot 9.81\ \frac{\text{m}}{\text{s}^2} \cdot 20.0\ \text{m} = 785\ \text{J}$

$v = \sqrt{\frac{2 \cdot E_k}{m}} = \sqrt{\frac{2 \cdot 785\ \text{J}}{4.00\ \text{kg}}} = \underline{\underline{19.8\ \frac{\text{m}}{\text{s}}}}$ $\quad$ <u>the same</u>

10. $E_p = E_k$ $\quad m \cdot g \cdot h = \frac{1}{2} \cdot m \cdot v^2$ $\quad g \cdot h = \frac{1}{2} \cdot v^2$ $\quad h = \frac{v^2}{2 \cdot g} = \frac{\left(7.6\ \frac{\text{m}}{\text{s}}\right)^2}{2 \cdot 9.81\ \frac{\text{N}}{\text{kg}}} = \underline{\underline{2.9\ \text{m}}}$

11. a) $E_p = m \cdot g \cdot h = 5.00\text{ kg} \cdot 9.81\,\frac{\text{m}}{\text{s}^2} \cdot 23.0\text{ m} = 1'128\text{ J}$

$$E_k = \frac{1}{2} \cdot m \cdot v^2 = \frac{1}{2} \cdot 5.00\text{ kg} \cdot \left(10.0\,\frac{\text{m}}{\text{s}}\right)^2 = 250\text{ J}$$

$$E_{total} = E_p + E_k = 1'128\text{ J} + 250\text{ J} = 1'378\text{ J} = \underline{\underline{1.38\text{ kJ}}}$$

b) $E_{p(4\text{ m})} = m \cdot g \cdot h = 5.00\text{ kg} \cdot 9.81\,\frac{\text{m}}{\text{s}^2} \cdot 4.00\text{ m} = \underline{\underline{196\text{ J}}}$

c) $E_{k(4\text{m})} = E_{total} - E_{p(4\text{ m})} = 1'378\text{ J} - 196\text{ J} = 1'182\text{ J} = \underline{\underline{1.18\text{ kJ}}}$

d) $v = \sqrt{\frac{2 \cdot E_k}{m}} = \sqrt{\frac{2 \cdot 1'182\text{ J}}{5.00\text{ kg}}} = \underline{\underline{21.7\,\frac{\text{m}}{\text{s}}}}$

e) $E_{k(15\text{ m/s})} = \frac{1}{2} \cdot m \cdot v^2 = \frac{1}{2} \cdot 5.00\text{ kg} \cdot \left(15.0\,\frac{\text{m}}{\text{s}}\right)^2 = 562\text{ J}$

$$E_{p(15\text{ m/s})} = E_{total} - E_{k(15\text{ m/s})} = 1'378\text{ J} - 562\text{ J} = 816\text{ J}$$

$$h = \frac{E_p}{m \cdot g} = \frac{0.25\text{ J}}{5.00\text{ kg} \cdot 9.81\,\frac{\text{m}}{\text{s}^2}} = \underline{\underline{16.6\text{ m}}}$$

12. $E_{start} = E_p + E_k = m \cdot g \cdot h + \frac{1}{2} \cdot m \cdot v^2$

$$= 0.025\text{ kg} \cdot 9.81\,\frac{\text{m}}{\text{s}^2} \cdot 3.32\text{ m} + \frac{1}{2} \cdot 0.025\text{ kg} \cdot (4.80\,\frac{\text{m}}{\text{s}})^2 = 1.102\text{ J}$$

25 % are transformed into internal energy; 75 % remain in the form of mechanical energy:

$0.75 \cdot 1.102\text{ J} = 0.827\text{ J}$

height the ball reaches with the remaining mechanical energy:

$$h = \frac{E}{m \cdot g} = \frac{0.827\text{ J}}{0.025\text{ kg} \cdot 9.81\,\frac{\text{m}}{\text{s}^2}} = \underline{\underline{3.4\text{ m}}}$$