## Solutions

Each answer shows the steps, then the **result**.

### 2.1

- $\Delta E_{\mathrm{P}} = mg\Delta h$
- $E_{\mathrm{K}} = \frac{1}{2}mv^2$

### 2.2

- $E_{\mathrm{K}} = \frac{1}{2}mv^2$

$$E_{\mathrm{K}} = \tfrac{1}{2}(1200\text{ kg})(15\text{ m s}^{-1})^2 = \mathbf{1.35 \times 10^5}\text{ J}$$

### 2.3

- $\Delta E_{\mathrm{P}} = mg\Delta h$

$$\Delta E_{\mathrm{P}} = (2.0\text{ kg})(9.81\text{ m s}^{-2})(1.5\text{ m}) = \mathbf{29}\text{ J}$$

### 2.4

- **kinetic energy**

### 3.1 C

- $E_{\mathrm{K}} \propto v^2$, so doubling $v$ makes KE **four** times larger

### 3.2

- work done $W = Fs = mas$
- from rest, $v^2 = 2as \Rightarrow s = v^2/(2a)$

$$W = ma \cdot \frac{v^2}{2a} = \tfrac{1}{2}mv^2 = E_{\mathrm{K}}$$

### 3.3

- $\frac{1}{2}mv^2 = mgh$

$$v = \sqrt{2gh} = \sqrt{2(9.81\text{ m s}^{-2})(1.8\text{ m})} = \mathbf{5.9}\text{ m s}^{\mathbf{-1}}$$

### 3.4

- from rest, $v^2 = 2gh$

$$v = \sqrt{2(9.81\text{ m s}^{-2})(0.20\text{ m})} = \mathbf{2.0}\text{ m s}^{\mathbf{-1}}$$

### 3.5

- GPE before: $mgh_1 = (0.20\text{ kg})(9.81\text{ m s}^{-2})(1.6\text{ m}) = 3.1\text{ J}$
- GPE after: $mgh_2 = (0.20\text{ kg})(9.81\text{ m s}^{-2})(1.2\text{ m}) = 2.4\text{ J}$
- energy transferred = 3.1 J − 2.4 J = **0.79** J

### 3.6

(a) $E_{\mathrm{K}} = \frac{1}{2}mv^2$

$$72\text{ J} = \tfrac{1}{2}(4.0\text{ kg})v^2 \Rightarrow v = \sqrt{36\text{ m}^2\text{ s}^{-2}} = \mathbf{6.0}\text{ m s}^{\mathbf{-1}}$$

(b) the block falls a further $x_0$ while compressing the spring, so $\Delta E_\mathrm{P} = mgx_0$

$$x_0 = \frac{12\ \mathrm{J}}{(4.0\ \mathrm{kg})(9.81\ \mathrm{m\ s^{-2}})} = \mathbf{0.31}\ \mathrm{m}$$

(c) all of it goes into the spring: $72\ \mathrm{J} + 12\ \mathrm{J} = \mathbf{84}\ \mathrm{J}$

(d) energy stored = area under the $F$–$x$ graph = a triangle: $E = \frac{1}{2}F_0 x_0$

$$F_0 = \frac{2 \times 84\ \mathrm{J}}{0.306\ \mathrm{m}} = \mathbf{5.5 \times 10^2}\ \mathrm{N}$$

(e)(i) spring **up** with $F_0$, weight **down**: $W = (4.0\ \mathrm{kg})(9.81\ \mathrm{m\ s^{-2}}) = 39\ \mathrm{N}$

- resultant $= 549\ \mathrm{N} - 39\ \mathrm{N} = \mathbf{5.1 \times 10^2}$ N **upwards**

(e)(ii)

$$a = \frac{F}{m} = \frac{510\ \mathrm{N}}{4.0\ \mathrm{kg}} = \mathbf{1.3 \times 10^2}\ \mathrm{m\ s^{-2}}$$

upwards

(f)

- axes labelled kinetic energy / J against compression / m
- starts at 72 J when $x = 0$, falls to zero at $x_0 = 0.31$ m, getting steeper as the spring force grows

(g) a greater drop height ⇒ **more KE** at contact ⇒ more energy stored; $E = \frac{1}{2}kx^2$ so $x_0$ is larger

- $F_0 \propto x_0$, so $a = (F_0 - mg)/m$ is larger too