

Solutions

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

2.1

- $\Delta E_P = mg\Delta h$
- $E_K = \frac{1}{2}mv^2$

2.2

- $E_K = \frac{1}{2}mv^2$
- $$E_K = \frac{1}{2}(1200 \text{ kg})(15 \text{ m s}^{-1})^2 = \mathbf{1.35 \times 10^5 \text{ J}}$$

2.3

- $\Delta E_P = mg\Delta h$
- $$\Delta E_P = (2.0 \text{ kg})(9.81 \text{ m s}^{-2})(1.5 \text{ m}) = \mathbf{29 \text{ J}}$$

2.4

- **kinetic energy**

3.1 C

- $E_K \propto v^2$, so doubling v makes KE **four** times larger

3.2

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

$$W = ma \cdot \frac{v^2}{2a} = \frac{1}{2}mv^2 = E_K$$

3.3

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

3.4

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

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

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 = $3.1 \text{ J} - 2.4 \text{ J} = \mathbf{0.79 \text{ J}}$

3.6

- (a) $E_K = \frac{1}{2}mv^2$

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

- (b) the block falls a further x_0 while compressing the spring, so $\Delta E_P = mgx_0$

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

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

- (d) energy stored = area under the F - x graph = a triangle: $E = \frac{1}{2}F_0x_0$

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

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

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

- (e)(ii)

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

upwards

- (f)

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

- (g) a greater drop height $\Rightarrow$ **more KE** at contact $\Rightarrow$ 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