Solutions

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

2.1

- $\Delta E_P = mg\Delta h$

$$\Delta E_P = 1200 \times 9.81 \times 18 = \mathbf{2.12 \times 10^5}\ \text{J}$$

2.2

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

$$E_K = \tfrac{1}{2} \times 0.058 \times 45^2 = \mathbf{59}\ \text{J}$$

2.3

(a) $E_K \propto v^2$, so the factor is $(30/20)^2 = \mathbf{2.25}$

(b) $\Delta E_K = \frac{1}{2} \times 1100 \times (30^2 - 20^2)$

- $\Delta E_K = \mathbf{2.75 \times 10^5}$ J

2.4

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

$$v = \sqrt{2 \times 9.81 \times 32} = \mathbf{25}\ \text{m s}^{-1}$$

2.5

- the gravitational field must be uniform: g does not change with height, as near the Earth's surface for small changes in height

3.1 B

- $E_K = p^2/2m$, so with the same momentum $E_K \propto 1/m$ and X, with twice the mass, has half the kinetic energy
- **C** would be true for the same speed, not the same momentum

3.2 C

- $\frac{1}{2}mv^2 = mgh$, so $h \propto v^2$ and doubling v needs four times the height
- **B** assumes that h is proportional to v

3.3

(a) the work done by the force is $W = Fs$ with $F = ma$

- from rest $v^2 = 2as$, so $s = v^2/2a$
- $W = ma \times \dfrac{v^2}{2a} = \frac{1}{2}mv^2$, and this work becomes the kinetic energy

(b) $E_K = \frac{1}{2} \times 0.45 \times 26^2 = 152$ J

- $F = \dfrac{E_K}{s} = \dfrac{152}{0.20} = \mathbf{760}$ N

(c) kinetic energy at the top $= \frac{1}{2} \times 0.45 \times 15^2 = 50.6$ J, so the gain in potential energy is $152.1 - 50.6 = 101.5$ J

- $mg\Delta h = 101.5$

$$\Delta h = \frac{101.5}{0.45 \times 9.81} = \mathbf{23}\ \text{m}$$

3.4

(a) $E_K = \frac{1}{2} \times 70 \times 9.0^2$

- $E_K = \mathbf{2.8 \times 10^3}$ J

(b) $mg\Delta h = 2835$ J

$$\Delta h = \frac{2835}{70 \times 9.81} = \mathbf{4.1}\ \text{m}$$

(c) she still has kinetic energy at the top, because she must keep moving horizontally over the bar

- some energy is transferred to thermal energy and sound in the pole and in her body, and by air resistance

(d) $\frac{1}{2}mv^2 = mg\Delta h$ with $\Delta h = 4.8 - 0.80 = 4.0$ m

$$v = \sqrt{2 \times 9.81 \times 4.0} = \mathbf{8.9}\ \text{m s}^{-1}$$

3.5

(a) to raise the mass at a steady speed, a force equal to its weight mg acts through the vertical distance Δh

- the work done $W = Fs = mg\Delta h$ is stored as gravitational potential energy, so $\Delta E_P = mg\Delta h$

(b) g decreases as the height increases, so the field is not uniform over 2000 km

(c) $\Delta h = 1650 - 1200 = 450$ m

$$\Delta E_P = 60 \times 9.81 \times 450 = \mathbf{2.6 \times 10^5}\ \text{J}$$

(d) food energy = useful work ÷ efficiency $= 2.65 \times 10^5/0.25$

- food energy $= \mathbf{1.1 \times 10^6}$ J