# Answers to Coursebook questions – Chapter 1.3

**1** The pressure is proportional to the temperature, so increasing the temperature by a factor of 4 will increase the pressure by the same factor.

**2** The kinetic energy is proportional to the square of the speed, so doubling the speed will increase the kinetic energy by a factor of $2^2 = 4$.

**3** The speed is proportional to the square root of the energy: if the energy doubles, the speed increases by a factor of $\sqrt{2}$.

**4** The distance is proportional to the square of the speed (for a constant force): if the speed doubles, the distance will increase by a factor of $2^2 = 4$.

**5** **a** The force will increase by a factor of $2 \times 2 = 4$.

**b** Doubling the charges means increasing the force by a factor of 4. However, the force stays the same, which means that the square of the separation must increase by a factor of 4. Hence the separation itself must increase by 2.

**6** The frequency is proportional to the square root of the tension: if the frequency triples, the square root of the tension must triple. Hence the tension must increase by a factor of 9.

**7** The period is proportional to the square root of the length: if the period doubles, the square root of the length doubles. This means that the length increases by $\sqrt{2}$.

**8** The frequency is proportional to the **inverse** of the square root of the mass. If the frequency **increases** by a factor of 4, then the square root of the mass **decreases** by a factor of 4, and so the mass decreases by a factor of $4^2 = 16$.

**9** The power is proportional to the fourth power of the temperature, so doubling the temperature means that the power increases by a factor of $2^4 = 16$.

**10** The period is proportional to the $\frac{3}{2}$ power of the distance. Hence if the distance increases by a factor of 2, the period will increase by a factor of $2^{3/2} = 2.83$. Therefore, the new period will be 2.83 years.

**11** **a** The undisturbed (equilibrium) height of the surface is 1.0 m.

**b** The period is approximately 1.4 s and so the frequency is

$$f = \frac{1}{1.4} = 0.7 \text{ Hz}.$$

**c** The maximum height from the equilibrium position of the surface is 0.30 m.

**12** **a** We plot $\frac{1}{a}$ versus $\frac{1}{b}$.

**b** The intercept on either axis is $\frac{1}{f}$.

**13** **a** A straight line through the origin.

**b** Now $P = c(\theta + 273)$, so a graph of pressure versus temperature ($\theta$) gives a straight line that intersects the temperature axis when $P = 0$, when $\theta = -273$ °C.

**14** We must get a proportionality. Since $T^2 = cR^3$ it follows that $T = \sqrt{c}R^{3/2}$ so we must plot $T$ versus $R^{3/2}$.

**15** Putting the two equations together gives $E_k = \frac{1}{2}mv^2$ and $v^2 = 2ad$. Hence $E_k = \frac{1}{2}m \times 2ad = mad$.

The kinetic energy is proportional to the distance. Plot kinetic energy versus distance.

**16** **a** The quantity $\phi$ is the negative of the vertical intercept.

**b** The quantity $h$ is the slope of the graph.

**c** They must have the same slope, since both slopes give the universal constant $h$, so the lines will be parallel.