Chapter 1.3

Q1 The pressure is proportional to temperature and so increasing the temperature by a factor of 4 will increase the pressure by the same factor.

Q2 The kinetic energy is proportional to the square of the speed so doubling the speed will increase the kinetic energy by a factor of $2^2 = 4$.

Q3 The speed is proportional to the square root of the energy so if the energy doubles the speed increases by a factor of $\sqrt{2}$.

Q4 The distance is proportional to the square of the speed (for a force that is constant) and so if the speed doubles the distance will increase by a factor of $2^2 = 4$.

Q5 (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. But 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.

Q6 The frequency is proportional to the square root of the tension. So if the frequency triples the square root of the tension must triple. Hence the tension must increase by a factor of 9.

Q7 The period is proportional to the square root of the length. So if the period doubles the square root of the length doubles. This means that the length increased by $\sqrt{2}$.

Q8 The frequency is proportional to the *inverse* of the square root of the mass. If the frequency *increases* by a factor of 4 the square root of the mass *decreases* by a factor of 4 and so the mass decreases by a factor of $4^2 = 16$.

Q9 The power is proportional to the fourth power of the temperature. So doubling the temperature means that the power increases by a factor of $2^4 = 16$.

Q10 The period is proportional to the 3/2 power of the distance. Hence if the distance increases by a factor of 2, the period will increase by a factor of $2^{3/2} = 2.83$, i.e. the new period will be 2.83 years.

Q11 (a) The undisturbed (equilibrium height of the surface) is 1.0m. (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.

Q12 (a) We plot $\frac{1}{a}$ versus $\frac{1}{b}$. (b) The intercept on either axis is $\frac{1}{f}$.

Q13 (a) A straight line through the origin. (b) Now $P = c(\theta + 273)$. So a graph of pressure versus temperature (θ) gives a straight line that intersects the temperature axis when $P = 0$, i.e. when $\theta = -273\ ^{\circ}\mathrm{C}$.

Q14 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 $R^{3/2}$.

Q15 Putting the two equations together gives

$E_k = \frac{1}{2}mv^2$ and $v^2 = 2ad$. Hence $E_k = \frac{1}{2}m \times 2ad = mad$. So the kinetic energy is proportional to distance. Plot kinetic energy versus distance.

Q16 (a) The quantity ϕ 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.