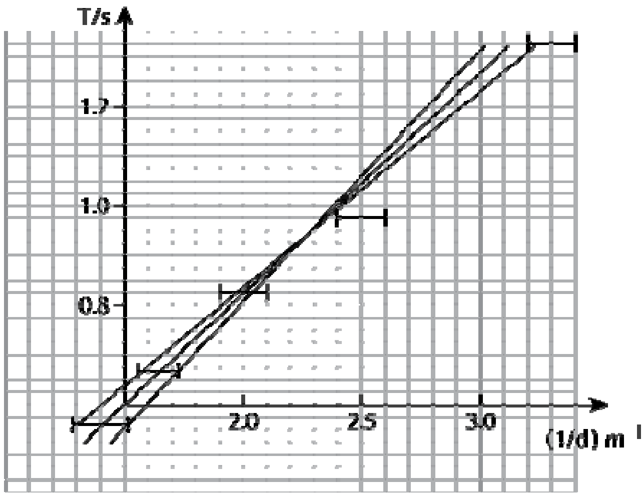
Mark scheme for Extension Worksheet – Topic 1, Worksheet 3

1 **a** Since $T = 2\pi\sqrt{\frac{kL}{d^2}}$ and d is constant we must plot either T versus $\sqrt{L}$; in which case the slope would be $\frac{2\pi}{d}\sqrt{k}$; [2]

or plot T^2 versus L; with a slope of $\frac{4\pi^2 k}{d^2}$. [2]

b See diagram below;



[1]

c The slope is $\frac{1.32-0.51}{3.30-1.25} = 0.395\ \text{s m}^{-1}$; the straight line of best fit is therefore $T = \frac{0.395}{d} + C$; to find C notice that the line goes through the point $(1.25, 0.51)$ and so $0.51 = 0.395 \times 1.25 + C \Rightarrow C = 0.016$, so that $T = \frac{0.40}{d} + 0.016$ to 2 s.f. [3]

d If the theory is correct we expect a straight-line graph that passes through the origin for T versus $1/d$; the line of best fit here is straight and passes very close to the origin so we may accept that the theory is verified (strictly we must draw the lines of maximum and minimum slope and see if these lines enclose the origin, which they do in this case). [2]

e The maximum and minimum lines drawn have slopes $m_{min} = 0.381\ \text{s m}^{-1}$ and $m_{max} = 0.409\ \text{s m}^{-1}$ giving an uncertainty in the slope of $\Delta m = \frac{m_{max} - m_{min}}{2} = 0.014 \approx 0.01\ \text{s m}^{-1}$; the slope is equal to $2\pi\sqrt{kL}$ so that

$k = \frac{m^2}{4\pi^2 L}$; and so $k = \frac{0.395^2}{4\pi^2 \times 0.30} = 1.317 \times 10^{-2}\ \frac{\text{s m}^{-1}}{\text{m}} = 1.317 \times 10^{-2}\ \text{s m}^{-2}$;

$\frac{\Delta k}{k} = 2\frac{\Delta m}{m} + \frac{\Delta L}{L} = 2 \times \frac{0.014}{0.395} + \frac{0.02}{0.30} = 1.37 \times 10^{-1}$;

$\Delta k = 1.37 \times 10^{-1} \times 1.317 \times 10^{-2} = 1.8 \times 10^{-3} \approx 0.002$;

hence $k = (1.317 \times 10^{-2} \pm 2 \times 10^{-3})\ \text{s m}^{-2} = (1.3 \pm 0.2) \times 10^{-2}\ \text{s m}^{-2}$. [6]