PHY2811 (2009) Group A

Test 1 solution

(1) (a) $\frac{\delta K}{K} = 2\frac{\delta v}{v} = 2\left(\frac{0.02}{2.34}\right) = 1.7\%$ or 2% (5 marks)

(b) $\frac{\delta K}{K} = \sqrt{\left(\frac{\delta m}{m}\right)^2 + 2^2\left(\frac{\delta v}{v}\right)^2} = 3\%$ or 3.2% (3.1% OK)

$K = 5.14$ J $\Rightarrow \delta K = 0.15$ or 0.1 J (0.2 OK) (5 marks)

(2) $47.5 \times 0.5\% + 0.2 = 0.4$ mV (10 marks)

(3) (a) 83 ± 1 or 83.1 ± 0.1 (5 marks)

(b) 14.2 ± 0.1 (5 marks)

(c) $6.75 \pm 0.5\%$ (5 marks)

(4) Due to human judgment of the start & end points, the error should be around 1- 3 mm.
Definitely wrong if ≤ 0.5 mm. (10 marks)

(5) (a) Error of T: instrument error = 0.001 s (4 marks)
human error: delayed due to reaction time (a systematic error) with random fluctuation (a random error) (6 marks)

(b) Measure several periods to minimize the human error. (4 marks)
The mass moves faster at the average position (or equilibrium position). Use that position for the start & stop of the timing. (1 mark)

(c) (i) T is more accurate than m. So take it as the x axis.
For a linear graph, we should plot m vs T^2. (5 marks)

$$m = \frac{k}{(2\pi)^2}T^2$$

OK if plot $\sqrt{m}$ vs. T.

(ii) Linear least square fit for m vs T^2: slope = 7.824 ± 0.074 or $7.82 \pm 0.07 = \frac{k}{(2\pi)^2}$

$\therefore k = 309$ N/m or kg/s^2

$\frac{\delta k}{k} = \frac{\delta(\text{slope})}{\text{slope}} = \frac{0.07}{7.82}$ & $\delta k = 3$ N/m (30 marks)

Note: This part (ii) is to test whether the student knows how to do linear least square fit. So even if the student plots T^2 vs m, or even T vs $\sqrt{m}$, we let them get the full marks if the procedure is OK.

For $T^2 = \frac{(2\pi)^2}{k}m$, linear least square fit:

slope = 0.128 ± 0.001 or 0.1278 ± 0.0012

slope $= \frac{(2\pi)^2}{k}$ $\therefore k = 308$ N/m or kg/s^2

$\frac{\delta k}{k} = \frac{\delta(\text{slope})}{\text{slope}} = \frac{0.001}{0.128}$ $\delta k = 2$ N/m or kg/s^2 or 0.8 %

(iii) Systematic error in m: the spring mass is not zero. (5 marks)