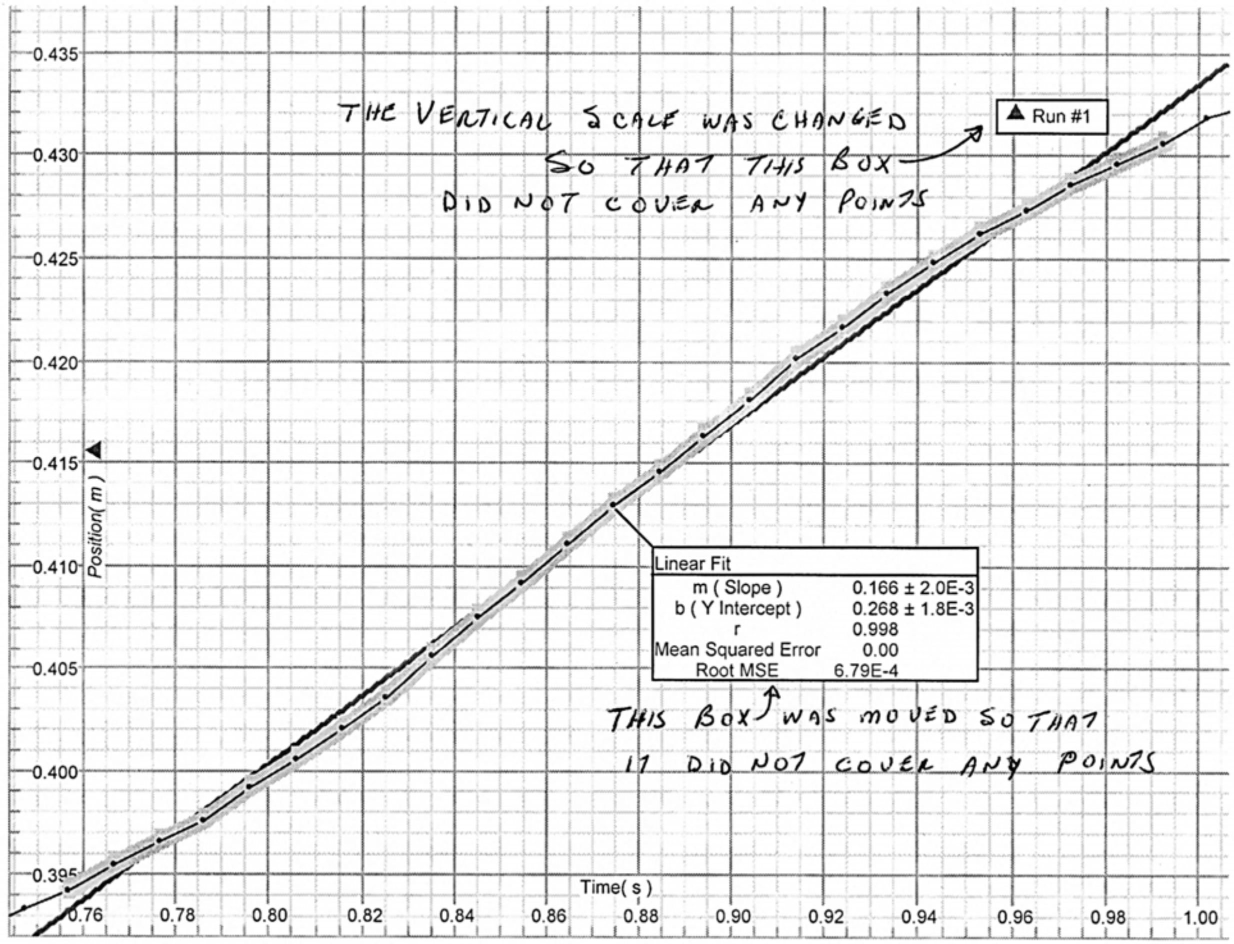
SOLUTIONS TO ASSIGNMENT 1 2003

1 a) **The trigger rate of the sensor is 100 Hz.**

1 b) **The speed comes from the coefficient m for the slope and is 0.166 ms^{-1}.**

1 c)



1 d) **For 10 cycles t = 7.43 s. thus T = 0.743 s.**

$$\omega = \frac{2\pi}{T} = \frac{2\pi}{0.743} = 8.457 \ s^{-1}$$

1 e) **For t = 0, y = 0.392**

y_0 = 0.412

A = 0.022

Thus 0.392 = 0.412 + 0.022 sin(ϕ)

ϕ = $\sin^{-1}$(-0.020/0.022) = -1.14 radian

1 f) **Comparing notations** $\sin(\omega t + \phi) \equiv \sin\left(\frac{2\pi t}{T} - \frac{2\pi C}{T}\right)$

$$\phi = -\frac{2\pi C}{T} = -\frac{2\pi \text{ x } 0.128}{0.745} = -1.08 \text{ radian}$$

3) **Since the standard deviation is larger than the reading error of the clock then the error in each measurement 0.23 seconds which is the standard deviation. However, you were asked for the error in the average. If you take more measurements, the average will not substantially change but you will get a better and better determination of the average. That is why the error in the average is the standard deviation divided by the square root of the number of measurements.**

$$\text{error in the average} = \frac{\text{S.D.}}{\sqrt{n}} = \frac{0.023}{\sqrt{9}} = 0.08$$

The error should normally be quoted to one significant figure. ERRTST will accept 0.077 but will take marks off for 0.0766 and even more marks off if you quote more significant figures.

4) **For the Casimir Effect we have:** $\frac{F}{A} = \frac{\pi^2}{240}\frac{\hbar^m c^n}{d^p}$.

Using the notation for dimensional analysis in Serway for the left hand side of the equation we have $\left[\frac{F}{A}\right] = \frac{\frac{\text{M L}}{\text{T}^2}}{\text{L}^2} = \frac{\text{M}}{\text{T}^2\,\text{L}}$. **(1) L.H.S.**

For the right hand side of the equation $[\hbar] = \frac{\text{M L}^2}{\text{T}}$, $[\text{c}] = \frac{\text{L}}{\text{T}}$ **and** $[d] = \text{L}$.

Therefore $\left[\frac{\hbar^m c^n}{d^p}\right] = \frac{\left(\frac{\text{M L}^2}{\text{T}}\right)^m \left(\frac{\text{L}}{\text{T}}\right)^n}{\text{L}^p} = \frac{\text{M}^m\,\text{L}^{2m+n-p}}{\text{T}^{m+n}}$ **(2) R.H.S.**

Equating the dimensions of the left and right hand sides we have $\frac{\text{M}}{\text{T}^2\,\text{L}} = \frac{\text{M}^{m}\,\text{L}^{2m+n-p}}{\text{T}^{m+n}}$.

Consider M

$\text{M}^1 = \text{M}^{m}$ **and therefore** $m = 1$.

Consider T

$\text{T}^2 = \text{T}^{m+n} = \text{T}^{1+n}$ **and therefore** $n = 1$.

Consider L

$\text{L}^{-1} = \text{L}^{2m+n-p} = \text{L}^{2+1-p} = \text{L}^{3-p}$ **and therefore p = 4.**

5 a) $[\text{I}_{\text{PHYSICS}}] = \left[\frac{\tau}{\alpha}\right] = \frac{\frac{\text{M L}^2}{\text{T}^2}}{\text{T}^{-2}} = \text{M L}^2$

5 b) $[\text{I}_{\text{CIV}}] = \left[\frac{\tau_{\text{M}}\,\text{y}}{\sigma}\right] = \left[\frac{\tau_{\text{M}}\,\text{y}}{\frac{\text{F}}{\text{Area}}}\right] = \frac{\left(\frac{\text{M L}^2}{\text{T}^2}\right)(\text{L})}{\left(\frac{\frac{\text{M L}}{\text{T}^2}}{\text{Area}}\right)} = \text{Area L}^2 = \text{L}^2\,\text{L}^2 = \text{L}^4$

5 c) **Area**