Protokoll

Schwerependel

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1 Physical Background for Task 1

Please see inserted pages.

2 Physical Background for Task 2

From Task 1 we know the solution to our equation of motion and therefore the value of T_0:

$$T_0 = 2\pi\sqrt{\frac{I}{Mgs}} \tag{1}$$

Also, we remember the Steiner theorem:

$$I_{new} = I_{known} + Ms^2 \tag{2}$$

where s is the displacement of the knew axis relative to the old.

We consider the center of mass and two displacements l_a and l_b of the axis. We know $l_a + l_b = d$, the distance between our two axis.

With (1) and (2) we get (3), which holds for l_a and l_b:

$$T_a = 2\pi\sqrt{\frac{I_a}{Mgl_a}} = 2\pi\sqrt{\frac{I_{cm} + Ml_a^2}{Mgl_a}} \tag{3}$$

By moving our additional mass on the pendulum we can move the center of mass. Assuming we can find a position (and it turns out that this position can easily be found) where our measured periods are the same, we find: $T_a = T_b$! Now the periods can easily be plugged in and the resulting equation yields:

$$I_{cm} = Ml_al_b \tag{4}$$

Pluggin that into our T_0 we find:

$$T = 2\pi\sqrt{\frac{I_{cm} + Ml_a^2}{Mgl_a}}$$

$$T = 2\pi\sqrt{\frac{Ml_al_b + Ml_a^2}{Mgl_a}}$$

$$T = 2\pi\sqrt{\frac{l_a + l_b}{g}}$$

$$T = 2\pi\sqrt{\frac{d}{g}}$$

$$\Longrightarrow g = d(\frac{2\pi}{T})^2 \tag{5}$$

Since d and T are easily measured, this is what we need!

3 Measurement - and Other Data

3.1 Measurement Data

Please see inserted page.

3.2 Equipment List

- Stangenpendel mit Zusatzmassen – Leybold
- Elektronische Quarz-Stoppuhr $1/100s$ & Lichtschrankensteuerung
- Quarz-Hand-Stoppuhr $1/100s$
- Metallmaßstab $500/1000mm$

3.3 Equipment Error Values

- Schneideabstand $L = (0.9941 \pm 0.002)m$
- Länge der Pendelstange $l = (1.6700 \pm 0.0005)m$
- Masse der Pendelstange $m_2 = (1.254 \pm 0.002)m$

3.4 Literature Values for g

- Potsdam: $g = 9.8127400(2)m/s^2$
- Flughafen Tempelhof: $g = 9.81282(1)m/s^2$

4 Auswertung

4.1 Task 1

In Task 1 the period T is measured in comparison to the amplitude of the pendulum. In *Graph 1* we evaluate our measurement results.

The input errors for $\frac{d^2}{s^2}$ and T are:

$$\Delta\frac{d^2}{s^2} = \sqrt{(\frac{2d}{s^2}\Delta d)^2 + (\frac{-2d^2}{s^3}\Delta s)^2} = \tag{6}$$

and

$$\Delta T = 0.001s \tag{7}$$

However the error in d^2/s^2 is almost too small to be plottet. From the Graph, the value of T_0 is found and an error is obtained:

$$T_0 = (1.972 \pm 0.002)s \tag{8}$$

Graph 1: Estimate of T

4.2 Task 2

In Task 2 the gravitational constant g is determined with equation (5). Please refer to the physical background section for a thorough motivation of this:

$$g = d(\frac{2\pi}{T})^2 \tag{9}$$

$$g = 0.9941m(\frac{2\pi}{2.0049s})^2 = 9.7647\frac{m}{s^2}$$

The error of g is:

$$\Delta g = 2\pi\sqrt{(\frac{1}{T^2}\Delta d)^2 + (\frac{-2d}{T^3}\Delta T)^2} \tag{10}$$

$$\Delta g = 0.0005\frac{m}{s^2}$$

The result is:

$$g = (9.7647 \pm 0.0005)\frac{m}{s^2}$$

5 Conclusion

In task 1 we measured the period to be $T_0 = 1.972(2)s$. For comparison with the theoretical value of a linear body we use:

$$T_0 = 2\pi\sqrt{\frac{I + ms^2}{msg}} \text{with} I = \tfrac{1}{12}mL^2$$

and find:

$$T_0 = 1.970s$$

This approximation seems to be legit and is congruent with our result.

In task 2 we determine the gravitational constant $g = 9.7647(5)ms^{-2}$. The literature value is $9.8128ms^{-2}$. Although our value of g seems reasonably good, our error has been calculated to be extremely small and so the triple error intervall still doesn't overlap with the literature value of g. However if friction has to be taken into account, it should lead us to measure a g that is smaller than the true g and that is the case here, so we guess that friction cannot be entirely ignored.