PHYS 101 – Final Lab Examination Solution Set

TOTAL (12 P)

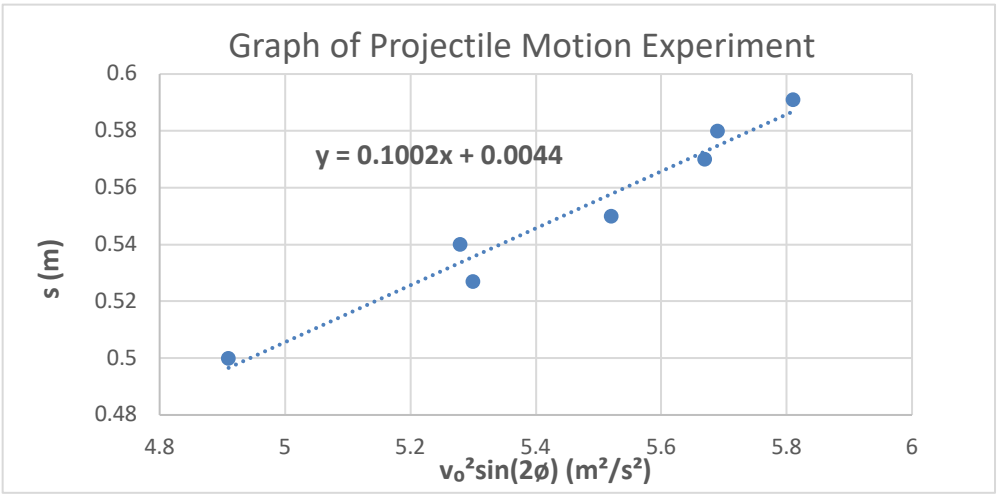
A projectile motion experiment is conducted with the purpose of investigating the trajectory equation of motion and to find an experimental value for the gravitational acceleration. In order to realize the quantitative relationship between the physical quantities involved within the experiment, the measured values are presented in tabular form as follows.

$v_0^2\sin(2\phi)$ (m^2/s^2)	s (m)
5.3	0.527
5.52	0.55
5.67	0.57
5.81	0.591
5.69	0.58
5.28	0.54
4.91	0.5

a) In the above dataset; ***s*** values are measured by using a ruler. Is the exact reading of a scale; in other words, the ***exact*** measurement of a physical quantity possible? ***State your reasoning.*** (2P)

Unfortunately an measurement with 100% accuracy is not possible, due to the limitations of the measureing devices. E.g. with a standard ruler your measurement accuracy is in the best case 0.5mm. On the other hand the reading from the measurement device may also have errors due e.g. the angle you look at the ruler.

The analysis of the recorded data above is carried out via the **least-squares line method** and the measurements are displayed graphically as shown below.



From the figure, we can identify that **s** and $\mathbf{v_0^2\sin(2\phi)}$ are ***linearly related*** which implies that they can be mathematically related through the equation

$$Y = mX + c.$$

As can also be seen from the graph, the least-squares line equation was obtained as

$$s = 0.1002v_0^2\sin(2\text{ø}) + 0.0044.$$

b) Write down the slope and the y-intercept of the least-squares line (with their units). (3P)

$$m = 0.1002\frac{s^2}{m}$$

$$c = 0.004m$$

c) Find the experimental value of gravitational acceleration (g_{exp}) by comparing the least-squares line equation obtained via the graphical analysis with $s = \frac{v_0^2\sin(2\text{ø})}{g}$. (2P)

$$m = \frac{1}{g} \Longrightarrow g_{exp} = \frac{1}{m} = \frac{1}{0.1002\frac{s^2}{m}} = 9.98\frac{m}{s^2}$$

d) If the theoretical value of gravitational acceleration is $g_{th} = 9.81\ m/s^2$, find the percentage error that indicates the accuracy of the conducted experiment. (2P)

$$\%error = \frac{g_{exp} - g_{theoretical}}{g_{theoretical}} = \frac{9.98\frac{m}{s^2} - 9.81\frac{m}{s^2}}{9.81\frac{m}{s^2}} = 0.017 = 1.7\%$$

e) What is the acceleration of the projectile at its maximum height? (1P)

$$\vec{a} = -g\,\hat{j}$$

f) What is the initial velocity of the projectile is $\vec{v}_i = (3\hat{\imath} + 4\hat{\jmath})\frac{m}{s}$, what is the velocity of the projectile at its maximum height and when it returns to its original height $y_f = y_i$? (2P)

$$\vec{v}_{maximum\ height} = 3\hat{\imath}\frac{m}{s}$$

$$\vec{v}_f(y_f) = (3\hat{\imath} - 4\hat{\jmath})\frac{m}{s},$$