THE COPPERBELT UNIVERSITY

SCHOOL OF MATHEMATICS AND NATURAL SCIENCES

DEPARTMENT OF PHYSICS

NAME:

ID:

GROUP:

EXPERIMENT: GRAPHICAL AND ERROR ANALYSIS.

Instructor :

Due Date :

TITLE: GRAPHICAL AND ERROR ANALYSIS

AIM: To analyse the motion of a car

APPARATUS: Not applicable.

DATA COLLECTION

Table 1: Sampled speed of a car for three trips

NO.	Trip 1 (m/s)	Trip 2 (m/s)	Trip 3 (m/s)
1	25	25	25
2	27	27	25
3	27	26	27
4	25	26	27
5	26	26	25
6	25	26	25
7	25	27	27

Table 2: Time of fall of a stone from different heights

Height h (cm)	Time of fall t (s)	$t^2 (s^2)$
100.0	0.4474	0.20016676
120.0	0.4922	0.24226084
130.0	0.5109	0.26101881
140.0	0.5321	0.28313041
150.0	0.5493	0.30173049
160.0	0.5673	0.32182929

DATA ANALYSIS

Table 1

QUESTION 1

Trip 1.

(i) $\Sigma V = (25 + 27 + 27 + 25 + 26 + 25 + 25)\, m/s$

$\Sigma V = \underline{180\, m/s}$

(ii) Mean $(\bar{V}) = \frac{1}{N} \sum_{i=1}^{N} Vi$

$N = 7$

$\sum_{i=1}^{N} Vi = 180$

$= \frac{1}{7}(180)$

$= \frac{180}{7}$

$= 25.71428571$

$\therefore \bar{V} = \underline{25.7\, m/s}$

(iii) V^2

NO	V (m/s)	V^2 (m^2/s^2)
1	25	625
2	27	729
3	27	729
4	25	625
5	26	676
6	25	625
7	25	625

(iv) $(\bar{V})^2 = (25.7)^2$

$= 660.49$

$\therefore (\bar{V})^2 = \underline{660.5\, m/s}$

Trip 2

(i) $\Sigma v = (25+27+26+26+26+26+27)\, m/s$

$\Sigma v = 183 m/s$

(ii) Mean $(\bar{v}) = \frac{1}{N}\sum_{i=1}^{N} v_i$

$N = 7$

$\Sigma v_i = 183$

$= \frac{1}{7}(183)$

$= 26.14285714\ m/s$

$\therefore \bar{v} = 26.1 m/s$

(iii) v^2

NO	v(m/s)	$v^2\ (m^2/s^2)$
1	25	625
2	27	729
3	26	676
4	26	676
5	26	676
6	26	676
7	27	729

(iv) $(\bar{v})^2 = (26.1)^2$

$= 681.21 m/s$

$= 681.2 m/s$

For Trip 3

(i) $\Sigma v = (25+25+27+27+25+25+27)\,m/s$

$= \underline{181\,m/s}$

(ii) Mean $(\bar{v}) = \frac{1}{N}\sum_{i=1}^{N} V_i$

$N = 7$

$\Sigma v_i = 181$

$= \frac{1}{7}(181)$

$= 25.85714286\,m/s$

$\therefore \bar{v} = \underline{25.9\,m/s}$

(iii) v^2

NO	$v\,(m/s)$	$v^2\,(m^2/s^2)$
1	25	625
2	25	625
3	27	729
4	27	729
5	25	625
6	25	625
7	27	729

(iv) $(\bar{v})^2 = (25.9)^2$

$= (25.9)^2 m/s$

$= 670.81\,m/s$

$= \underline{670.8\,m/s}$

QUESTION 2

For Trip 1

1. N

(i) percent error in V

percent error $= \frac{\delta \bar{V}}{\bar{V}} \times 100\%$

$$\delta \bar{v} = \frac{1}{N} \Sigma |(v_i - \bar{v})|$$

$$\delta \bar{v} = \frac{1}{7}\Big[(25-25.7)+(27-25.7)+(27-25.7)+(25-25.7)+(26-25.7)+(25-25.7)+(25-25.7)\Big]$$

$$\delta \bar{V} = \frac{1}{7}(0.7+1.3+1.3+0.7+0.3+0.7+0.7)$$

$$= \frac{1}{7}(5.7)$$

$$= 0.8142857143$$

$$\therefore \delta \bar{V} = 0.814$$

percent error $= \frac{\delta \bar{V}}{\bar{V}} \times 100\%$

$$= \frac{0.814}{25.7} \times 100\%$$

$$= 3.167315175\%$$

$\therefore$ % error $= \underline{3.2\%}$

(ii) Absolute error

Absolute error $= \frac{(\%\text{ error in } V) \times \bar{V}}{100\%}$

$$= \frac{3.2\% \times 25.7\,m/s}{100\%} = 0.8224\,m/s$$

$$= \underline{0.82\,m/s}$$

2. V^2

(i) percent error in V^2

$$\text{percent error} = \frac{\delta \bar{V}^2}{\bar{V}^2} \times 100\%$$

$$\delta \bar{V}^2 = \frac{1}{N} \Sigma |(V^2 - \bar{V}^2)|$$

$$= \frac{1}{7} [(625-660.5)+(729-660.5)+(729-660.5)+(625-660.5)+(676-660.5)+(625-660.5)+(625-660.5)]$$

$$\delta \bar{V}^2 = \frac{1}{7}(35.5+68.5+68.5+35.5+15.5+35.5+35.5)$$

$$= \frac{1}{7}(294.5)$$

$$= 42.07142857$$

$$\therefore \delta \bar{V}^2 = 42.1$$

$$\text{percent Error} = \frac{\delta \bar{V}^2}{\bar{V}^2} \times 100\%$$

$$= \frac{42.1}{660.5} \times 100\%$$

$$= 6.373959122\%$$

$$\therefore \quad \%\ \text{error} = \underline{\underline{6.4\%}}$$

(ii) Absolute Error

$$\text{Absolute error} = \frac{(\%\ \text{error in } V^2) \times \bar{V}^2}{100\%}$$

$$= \frac{6.4\% \times 660.5\,m/s}{100\%}$$

$$= 42.272\,m/s \Rightarrow \underline{\underline{42.3\,m/s}}$$

For Trip 2

1. V

(i) percent error in v

percent Error $= \frac{\delta \bar{v}}{\bar{v}} \times 100\%$

$$\delta \bar{v} = \frac{1}{N}\sum |(v_i - \bar{v})|$$

$$\delta \bar{v} = \frac{1}{7}\left[(25-26.1)+(27-26.1)+(26-26.1)+(26-26.1)+ (26-26.1)+(26-26.1)+(27-26.1)\right]$$

$$= \frac{1}{7}(1.1+0.9+0.1+0.1+0.1+0.1+0.9)$$

$$= \frac{1}{7}(3.3)$$

$$= 0.471428571 4$$

$$\therefore \delta \bar{v} = 0.471$$

percent error $= \frac{\delta \bar{v}}{\bar{v}} \times 100\%$

$$= \frac{0.471}{26.1} \times 100\%$$

$$= 1.806239737\%$$

$\therefore$ % error $= \underline{1.8\%}$

(ii) Absolute Error

Absolute error $= \frac{(\%\text{ error in } v) \times \bar{v}}{100\%}$

$$= \frac{1.8\% \times 26.1\,m/s}{100\%}$$

$$= 0.4698\,m/s$$

$$= \underline{0.47\,m/s}$$

2. V^2

(i) percent error in V^2

$$\text{percent error} = \frac{\delta \bar{V}^2}{\bar{V}^2} \times 100\%$$

$$\delta \bar{V}^2 = \frac{1}{N} \Sigma |(V^2 - \bar{V}^2)|$$

$$= \frac{1}{7}[(625-681.2)+(729-681.2)+(676-681.2)+(676-681.2)+(676-681.2)+(676-681.2)+(729-681.2)]$$

$$\delta \bar{V}^2 = \frac{1}{7}(56.2+47.8+5.2+5.2+5.2+5.2+47.8)$$

$$= \frac{1}{7}(172.6)$$

$$\therefore \delta \bar{V}^2 = 24.65714286$$

$$= 24.7$$

$$\text{percent error} = \frac{\delta \bar{V}^2}{\bar{V}^2} \times 100\%$$

$$= \frac{24.7}{681.2} \times 100\%$$

$$= 3.625954198\%$$

$$\therefore \%\ \text{error} = \underline{\underline{3.6\%}}$$

(ii) Absolute Error

$$\text{Absolute error} = \frac{(\%\ \text{error in } V^2) \times \bar{V}^2}{100\%}$$

$$= \frac{3.6\cancel{\%} \times 681.2\,m/s}{100\cancel{\%}}$$

$$= 24.5232\,m/s$$

$$= \underline{\underline{24.5\,m/s}}$$

For Trip 3

1) v

(i) percent error in v

$$\% \text{ error} = \frac{\delta \bar{v}}{\bar{v}} \times 100\%$$

$$\delta \bar{v} = \frac{1}{N} \Sigma |(v_i - \bar{v})|$$

$$= \frac{1}{7} [(25-25.9)+(25-25.9)+(27-25.9)+(27-25.9)+ (25-25.9)+(25-25.9)+(27-25.9)]$$

$$= \frac{1}{7}(0.9+0.9+1.1+1.1+0.9+0.9+1.1)$$

$$= \frac{1}{7}(6.9)$$

$$= 0.9857142857$$

$$\therefore \delta \bar{v} = 0.986$$

$$\text{percent error} = \frac{\delta \bar{v}}{\bar{v}} \times 100\%$$

$$= \frac{0.986}{25.9} \times 100\%$$

$$= 3.805846663\%$$

$$\therefore \% \text{ error} = \underline{3.8\%}$$

(ii) Absolute error

$$\text{Absolute error} = \frac{(\% \text{ error in } v) \times \bar{v}}{100\%}$$

$$= \frac{3.8\% \times 25.9 \, m/s}{100\%}$$

$$= 0.9842 \, m/s$$

$$= \underline{0.98 \, m/s}$$

2. v^2

(i) percent error in v^2

$$\% \text{ error} = \frac{\delta \bar{v}^2}{\bar{V}^2} \times 100\%$$

$$\delta \bar{v}^2 = \frac{1}{N} \Sigma |(v^2 - \bar{v}^2)|$$

$$\delta \bar{v}^2 = \frac{1}{7} [(625 - 670.8) + (625 - 670.8) + (729 - 670.8) + (729 - 670.8) + (625 - 670.8) + (625 - 670.8) + (729 - 670.8)]$$

$$\delta \bar{v}^2 = \frac{1}{7} (45.8 + 45.8 + 58.2 + 58.2 + 45.8 + 45.8 + 58.2)$$

$$= \frac{1}{7}(357.8)$$

$$= 51.11428571$$

$$= 51.1$$

$\therefore$ percent error $= \frac{\delta \bar{v}^2}{\bar{V}^2} \times 100\%$

$$= \frac{51.1}{670.8} \times 100\%$$

$$= 7.61989268\%$$

% error $= \underline{7.6\%}$

(ii) Absolute error

$$\text{Absolute error} = \frac{(\% \text{ error in } v^2) \times \bar{v}^2}{100\%}$$

$$= \frac{7.6\% \times 670.8 \, m/s}{100\%}$$

$$= 51.11428571 \, m/s$$

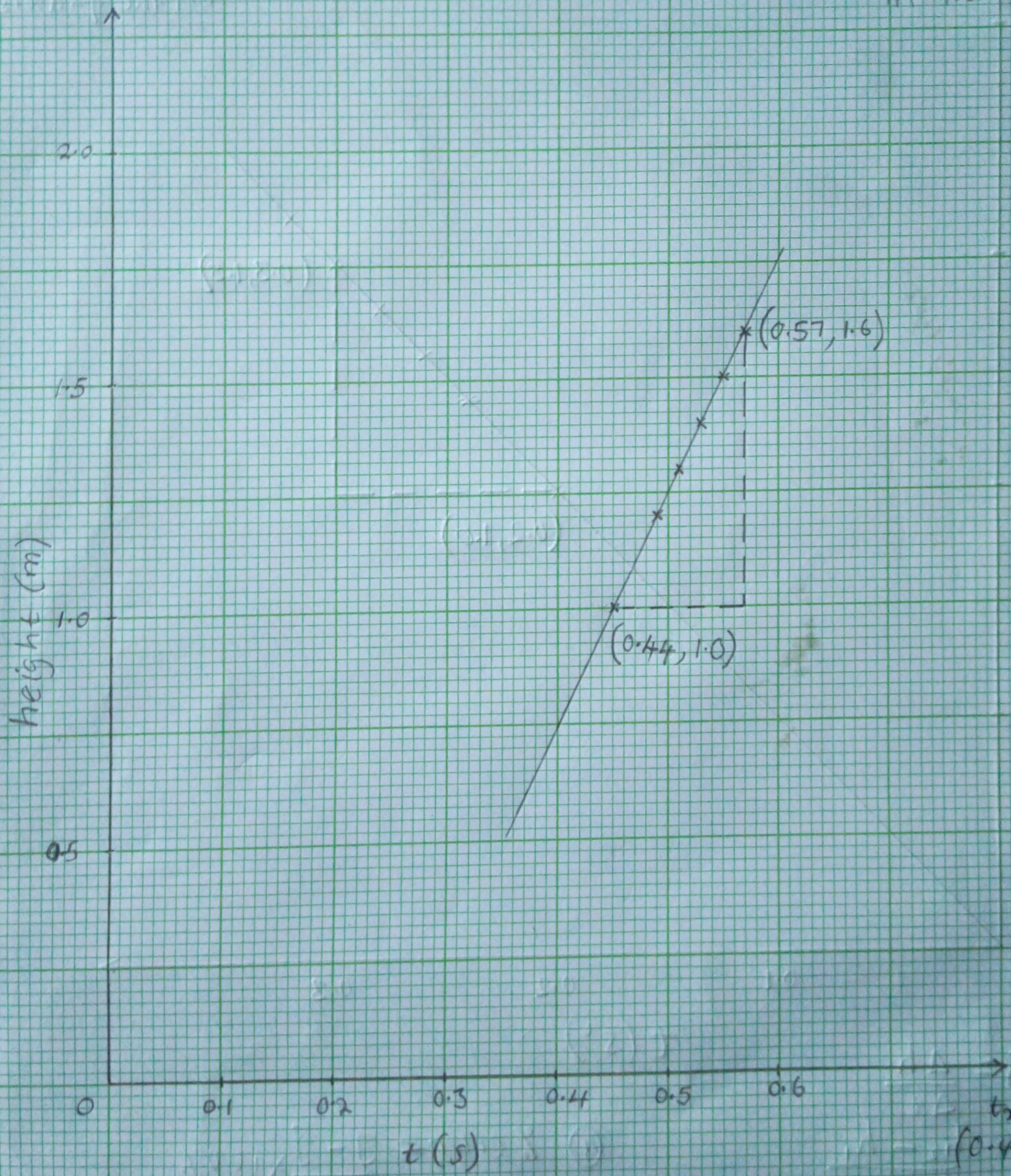
$$= \underline{51.1 \, m/s}$$

TITLE: GRAPH OF HEIGHT VS TIME

SCALE

2cm — 0·1 units in the x-axis

4cm — 0·5 units in the y-axis



t_2 h_2
(0·44, 1·0)
(0·57, 1·6)
t_1 h_1

Average speed $= \dfrac{\Delta h}{\Delta t} = \dfrac{|(1{\cdot}0 - 1{\cdot}6)|\,m}{|(0{\cdot}44 - 0{\cdot}57)|\,s}$

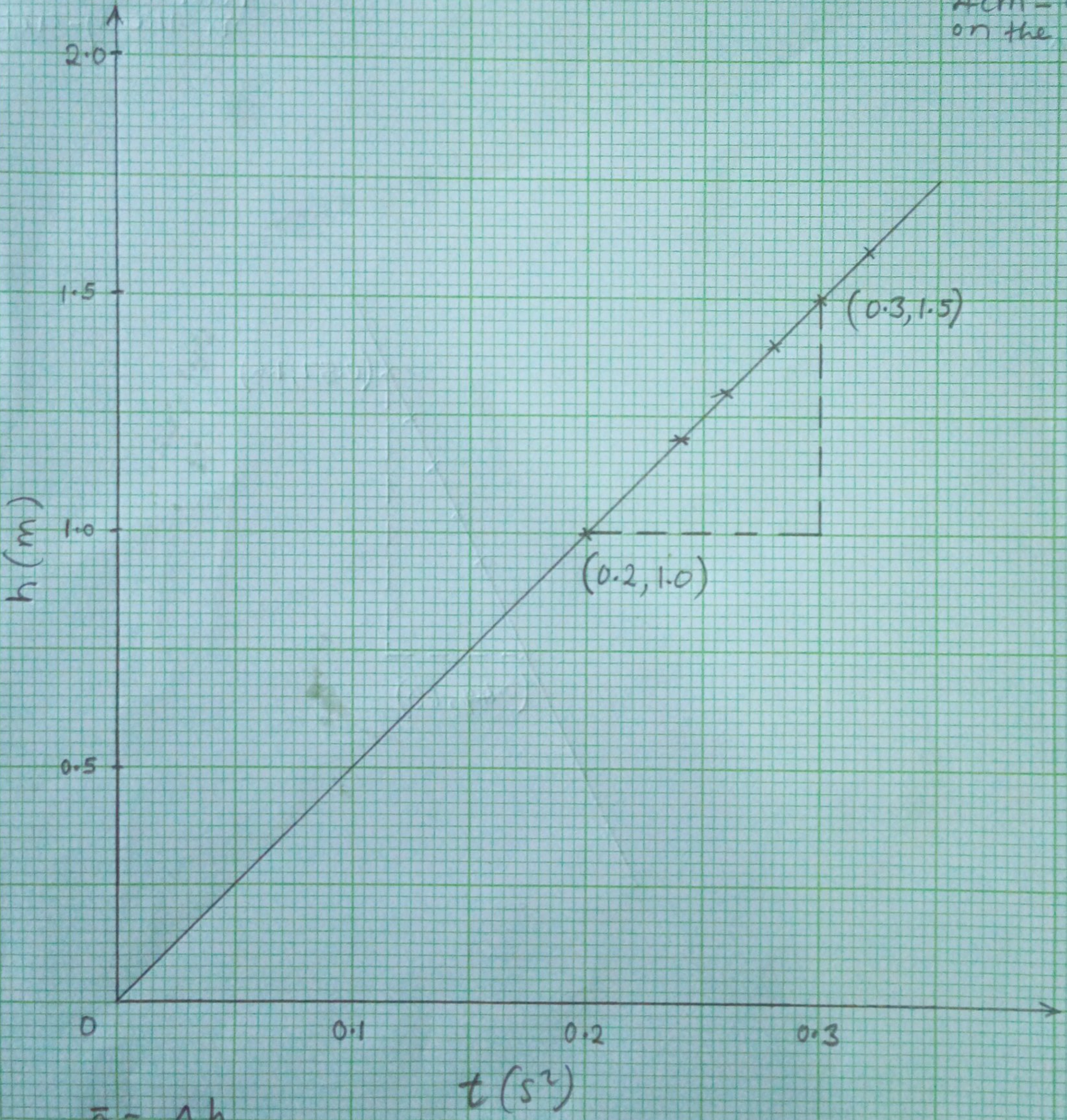
$= \dfrac{h_2 - h_1}{t_2 - t_1} = \dfrac{0{\cdot}6\ m}{0{\cdot}13\ s} = \underline{\underline{4{\cdot}62\,m/s}}$

SCALE

TITLE: GRAPH OF HEIGHT VS TIME SQUARED

4cm – 0.1 units on the x-axis

4cm – 0.5 units on the y-axis.



$$\bar{g} = \frac{\Delta h}{\Delta t}$$

$$= \frac{h_2 - h_1}{t_2 - t_1}$$

$$= \frac{(1.5 - 1.0)\,m}{(0.3 - 0.2)\,s^2}$$

$$= \frac{0.5\,m}{0.1\,s^2} = 5\,m/s^2$$

4) $\%\ error = \frac{g - \bar{g}}{g} \times 100\%$

$$= \frac{(9.81 - 5)\,m/s^2}{9.81\,m/s^2} \times 100\%$$

$$= 49.0316004\%$$

$\therefore \%\ error = 49.0\%$

DISCUSSION

During the experiment of analysing the motion of the car some errors were encountered and one of them was personal errors where the observer may have not taken the readings correctly. Measurements have always a degree of uncertainity due to random and systematic errors hence several measurements or readings were taken to come up with the main value. The percentage errors of trip 1, trip 2, and trip 3 were 3.2%, 1.8% and 3.8% respectively. These errors can be minimized or reduced by reducing personal bias when taking the measurements and also reduce on the rounding off of numbers when calculating the measurements.

For the second part the acceleration of the failing stone was also taken at different heights to get the most accurate values of time but due to errors the values were taken with some uncertainity or significant figures.

CONCLUSION

The experiment was successfully done and the percentage and absolute errors in v and v^2 were calculated for all the trips. The graphs of height vs time and height vs time squared were plotted. Both graphs gave straight lines which were used to calculate the average speed which was 4.62 m/s and the average acceleration which was 5.0 m/s². This acceleration value was partially close to the accepted value of 9.81 m/s². The percentage error of the stone failing from different heights was very ~~high~~ large and this was due to errors in timing by the observer and the accuracy of the instrument used.

REFERENCES

1. Serway (2014), <u>physics for scientists and engineers</u> (9th edition), USA.
2. John O. R (2013), <u>principles of physics: for scientists</u>, Springer heidelberg new york USA.
3. Nelkon and parker (2005), <u>Advanced level physics</u> united kingdom.