**Birzeit University**

**Physics department**

**Physics 211**

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**Experiment number: (3)**

**Experiment name: Newton’s laws of motion**

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**Instructor: Dr. Wael .Q**

**Abstract:**

**The aim of this experiment is to verify Newton’s first and second laws by using an air track and manipulating distance and masses to see if a match is found in the speed at the firs law and o see if the summation of the mass times the acceleration is always the same for the second law .**

**Theory:**

**The first law of Newton’s laws states that a moving object s remains moving unless diverted by external force.**

**V(t) = at**

**The second law states that the total force is directly proportional to the systems acceleration** $\vec{F }=m\vec{a}$

$\vec{F }$ **= m** $\vec{g }$ **= (M+m) a**

$\vec{g } $**=9.8 (m/s2)**

**V(t) =[m** $\vec{g}$**/(m+M)]**

$\vec{d }$**= ½[ m** $\vec{g}$**/(m+M)] t2**

**V= x/**$∆t$

**V= at**

**Procedure:**

**Part 1:**

1. **start the air track.**
2. **Set up both timers to measure** $∆t.$
3. **Lunch the cart along the track and read the time on the timers of both photocells**
4. **Calculate V for both and compare V=d/**$∆t$

**Part 2A:**

1. **start the air track.**
2. **Setup timer 1 to measure t and timer 2 to measure** $∆t $**.**
3. **Start the system M,M’ into motion by triggering the release mechanism (magnet)**
4. **Change the position of the photocell (change d) record d,t and** $∆t$
5. **Repeat the four steps for five different values of d.**

**Part 2b:**

1. **start the air track.**
2. **Setup timer 1 to measure t and timer 2 to measure** $∆t $**.**
3. **Load the cart M with additional weights .**
4. **Maintain constant d, Start the system M,M’ into motion by triggering the release mechanism.**
5. **Transfer weights from M to M’, changing M’ but keeping total M+M’ constant.**
6. **Repeat step five for three different values of M’.**

**Data:**

 **d =2.4 cm =0.024 m**

**first part:**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Attempt** | **∆t1** | **∆t2** | **v1** | **v2** |
| **1** | **0.018** | **0.018** | **1.333333** | **1.333333** |
| **2** | **0.044** | **0.043** | **0.545455** | **0.55814** |
| **3** | **0.027** | **0.026** | **0.888889** | **0.923077** |
| **4** | **0.025** | **0.025** | **0.96** | **0.96** |
| **5** | **0.023** | **0.022** | **1.043478** | **1.090909** |

**Second part 2A**

|  |  |  |  |
| --- | --- | --- | --- |
| ∆t | T | v (m/s) | d (m) |
| 0.03 | 0.973 | 0.421377 | 0.41 |
| 0.026 | 1.142 | 0.503503 | 0.575 |
| 0.023 | 1.266 | 0.545024 | 0.69 |
| 0.02 | 1.389 | 0.601152 | 0.835 |
| 0.019 | 1.469 | 0.633084 | 0.93 |

**Second part 2B**

**d= 59 cm**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| ∆t | T | M (kg) | M' (kg) | a (m/s2) |
| 0.017 | 0.781 | 0 | 0.05 | 1.93455 |
| 0.019 | 0.868 | 0.01 | 0.04 | 1.566183 |
| 0.022 | 1.011 | 0.02 | 0.03 | 1.154462 |
| 0.027 | 1.244 | 0.03 | 0.02 | 0.762502 |
| 0.041 | 1.863 | 0.04 | 0.01 | 0.339982 |

**Data analysis :**

**Part 1:**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Attempt** | **∆t1** | **∆t2** | **v1** | **v2** | **v2-v1** | **((v2+v1)/2)V avg** | **((v2-v1)/ V avg)** |
| **1** | **0.018** | **0.018** | **1.333333** | **1.333333** | **0** | **1.333333333** | **0** |
| **2** | **0.044** | **0.043** | **0.545455** | **0.55814** | **0.012685** | **0.55179704** | **0.022988506** |
| **3** | **0.027** | **0.026** | **0.888889** | **0.923077** | **0.034188** | **0.905982906** | **0.037735849** |
| **4** | **0.025** | **0.025** | **0.96** | **0.96** | **0** | **0.96** | **0** |
| **5** | **0.023** | **0.022** | **1.043478** | **1.090909** | **0.047431** | **1.067193676** | **0.044444444** |

**Part 2 A:**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **∆t(s)** | **t( s)**  | **v (m/s)** | **d (m)** | **Log t** | **log v** | **log d** |
| **0.03** | **0.973** | **0.421377** | **0.41** | **-0.01189** | **-0.37533** | **-0.38722** |
| **0.026** | **1.142** | **0.503503** | **0.575** | **0.057666** | **-0.298** | **-0.24033** |
| **0.023** | **1.266** | **0.545024** | **0.69** | **0.102434** | **-0.26358** | **-0.16115** |
| **0.02** | **1.389** | **0.601152** | **0.835** | **0.142702** | **-0.22102** | **-0.07831** |
| **0.019** | **1.469** | **0.633084** | **0.93** | **0.167022** | **-0.19854** | **-0.03152** |

**Part 2 B:**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **1** | **∆t** | **t** | **M (kg)** | **M' (kg)** | **a (m/s2)** |
| **2** | **0.017** | **0.781** | **0.20** | **0.05** | **1.93455** |
| **3** | **0.019** | **0.868** | **0.21** | **0.04** | **1.566183** |
| **4** | **0.022** | **1.011** | **0.22** | **0.03** | **1.154462** |
| **5** | **0.027** | **1.244** | **0.23** | **0.02** | **0.762502** |
| **6** | **0.041** | **1.863** | **0.24** | **0.01** | **0.339982** |

**From part one we notice that v2 and v1 are either identical or very close to each other and deviation from the first law is very small so the results are very close to the theoretical perspective showing that first law applies here.**

 **For part 2 (A) :**

**From fig of log v vs log t ,using the equations in theory**

**Log v =log a +log t**

**The theoretical value is of the slope should be 1, from the graph its 0.977**

**The y intercept =log a =** **0.3608 , a= 2.3 (cm/s2)**

**From graph of log d vs log t**

**D=1/2[at2]🡪 log d=log(a/2)+2log t**

**So theoretically the slope should be 2**

**From the graph the slope is 1.977**

**The y intercept =log a/2 =** **0.3608**

**So a= 2.3 cm/s2**

**Part 2 B:**

**From the graph of M’\*g vs a**

**Slope =M+M’= 0.25 kg theoretically**

**From the graph slope =** **0.2453 kg**

**Main results:**

* **The first part :**

**V1,V2 are very close or a an exact match .i.e. 1st law is valid .**

* **The second part 2A :**

**Log v= log (a) +log (t)**

**Slope =1, from graph 0.977**

**a= 2.3 \*10^-2 (m/s2)**

**From graph of log d vs log t**

**a= 2.3 \*10^-2 (m/s2)**

**since the accelerations match then both equations are valid and can be used to validate the first law.**

**part 2 B:**

**Slope =M+M’= 0.25kg theoretically**

**Slope from the graph =** **0.2453**

**Percentage error =[(theo-exp)/theo]\*100 = [(0.25-0.2453)/0.25]\*100 = 1.9%**

**Which is close to the theoretical value**

 **Discussion of results:**

* **In the first part the velocities are very close and from that validation of the first law is obtained .**
* **From the comparison of the slopes of the graphs in the second part the acceleration obtained was a match indicating that d=1/2[at2],and V=at are good approximation for the relationship relating a to V and d validating the first law .**
* **Slope of graph in part 2 B is very close to M+M’ indicating that the second law is valid .**

**Sources of error:**

* **Friction forces .**
* **Air resistance .**
* **Random error in the Timer.**
* **The air track might have been a little bent down which affects the acceleration .**

**Conclusion :**

**Newton’s laws of motion are valid at Birzeit university on the scale of the study .**