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Faculty of sciences - common Basic of matter sciences

2nd PRACTICAL WORK: NEWTON'S LAWS OF MOTION

Date: ………/………./……..

	First Name	Family name	Subgroup	Professor's name
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Purpose

These experiments involve an endeavor to comprehend and elucidate the motion of objects and the effects of forces acting on them by applying Newton's three laws. Through this research, our objectives are as follows:

1- To offer a scientifically accurate explanation for the state of rest or constant motion of an object, as outlined in the first law. 2- To clarify alterations in the velocity of an object moving on an inclined plane, as dictated by Newton's second law. 3- To illustrate the principle of action and reaction as described by Newton's third law.

THEORETICAL REMINDER OF BASIC CONCEPTS

Newton's Laws of Motion are a set of three fundamental principles in classical physics that describe the relationship between the motion of objects and the forces acting on them. These laws provide a framework for understanding the motion of objects and the interactions between them. These laws were formulated by the English physicist Sir Isaac Newton in the 17^{th} century and remain a cornerstone of classical mechanics. Here are the explanations of Newton's Laws of Motion.

A. ***Newton's First Law (The Law of Inertia):*** If an object is at rest, it will remain at rest unless acted upon by external forces (or the sum of the forces acting upon it equal to zero). If it is in motion at a constant velocity in a specific direction, it will continue moving at that velocity and direction unless acted upon by external forces (the sum of the forces acting upon it equal to zero).

B. ***Newton's Second Law*** Newton's Second Law states that the change in velocity of an object is directly proportional to the sum of external forces acting on it and inversely proportional to its mass. The second law of Newton can be formulated mathematically as follows:

$$\sum \vec{F}_{ext} = \frac{m\, d\vec{v}}{dt}$$

C. **Newton's Third Law (Action and Reaction)**

For every action (force) on an object, there is an equal and opposite reaction (force). The third law of Newton can be formulated mathematically as follows:

$$\vec{F}_{A/B} = -\vec{F}_{B/A}$$

THEORETICAL PART

An object of mass (m= 0.2 Kg) is placed on a frictionless inclined plane with an angle of inclination $\boldsymbol{\theta = 30^0}$ relative to the horizontal as shown in the **figure(1).** The object is initially at rest at the top of the incline. You are asked to plot the changes in speed as a function of time as the object slides down the incline. The changes in the velocity $\boldsymbol{v}$ of the body are given as a function of time as in the following table:

t(s)	0.202	0.286	0.350	0.404	0.452	0.495	0.534
$\boldsymbol{v}$ **(m/s)**	1.00	1.40	1.72	1.98	2.21	2.43	2.62

- Represent the forces acting on the body and project them onto the (Ox) and (Oy) axes.

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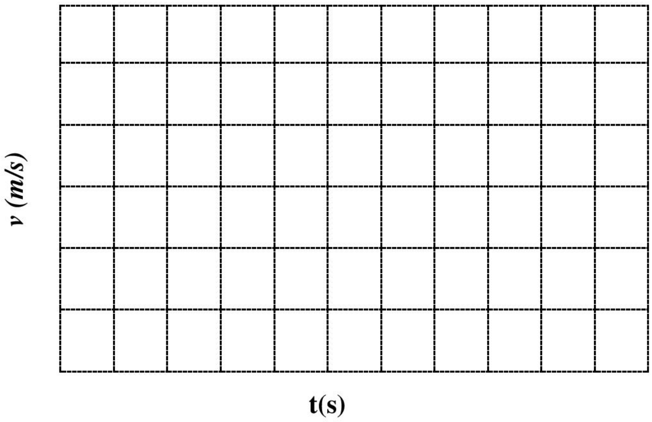
- Based on Newton's Second Law, derive the time-dependent equations for the motion of the body.

- Draw a velocity-time graph and then deduce the value of gravitational acceleration



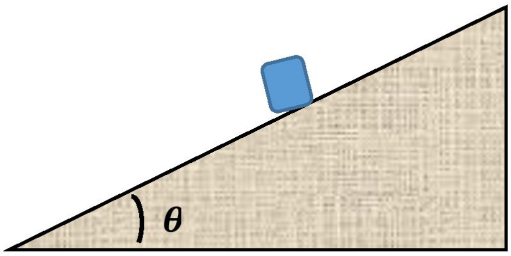


Figure-01

PRACTICAL PART

1. *Experimental Verification of Newton's First Law*

The experimental setup depicted in the ***figure (01)*** below consists of an air pump, an air track, a cart equipped with a 5mm width display indicator, a digital timer, and two optical barriers.

figure (01)

To experimentally verify Newton's First Law, you can follow the steps below:

1. Place the cart on the air track in such a way that it remains stationary and does not move.
2. Turn on the air pump and ensure that air is being emitted from the holes in the air track.
3. Push the cart until it passes both optical barriers.
4. As the cart crosses the optical barrier, the indicator interrupts (cuts off) the light rays between the two ends of the optical barrier, and the red light in the optical barrier goes out for a period of time equal to "dt". During this period, the cart will have traveled a distance dx, equal to the width of the indicator carried on the cart.

a- *Record the time (dt) for each optical barrier, and then formulate an expression for the cart's velocity as a function of both dx and dt.*

b- *Calculate the cart's velocity v when it passes the first and second barriers and record the results in the table.*

	first optical barrier	Second optical barrier
dt		
$v = \dots\dots\dots$		

c- *Compare between the two velocities.*

d- *Repeat the same previous steps 1, 2, and 3, and when the cart passes the first optical barrier, cut off the air supply to the track using the air pump. You will notice that the cart does not come to an immediate stop but continues moving for a certain duration before coming to a stop.*

e- *Record the time (dt) for each optical barrier, and calculate the cart's velocity v when it passes the first and second barriers and record the results in the table.*

	first optical barrier	Second optical barrier
dt		
$v = \dots\dots\dots$		

d- *Compare between the two velocities and explain the reason for the cart's stopping.*

e- *What do you deduce from this experiment?*

I) Place an object on millimeter paper and follow these steps:

Assign three students to use dynamometers to apply varying forces from different directions to the object while keeping it stationary, as shown in the ***figure (02).***

a- *Record the force values exerted by each student.*

1st student $\|\vec{F}\| =$ *2nd student* $\|\vec{F}\| =$ *3rd student* $\|\vec{F}\| =$

b- *Represent these forces using an appropriate graphical scale and draw the resultant force.*

c- *What do you deduce from this experiment?*

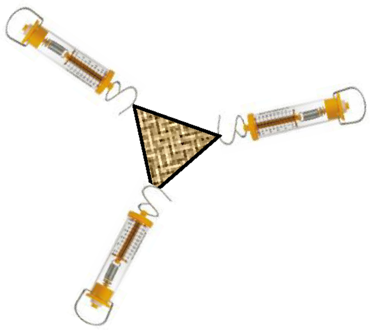
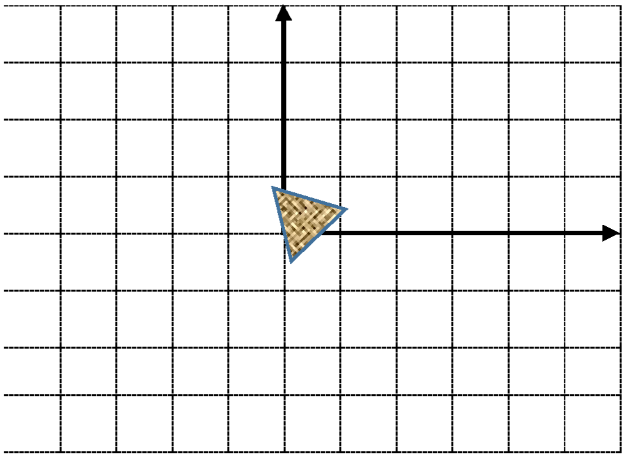


figure (02)



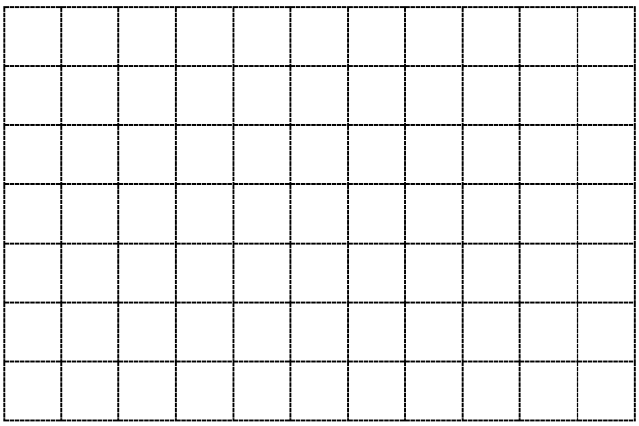
II) Experimental Verification of Newton's Second Law

*Use the experimental setup depicted in **figure (1)** and incline the air track at a specific angle. Turn on the air pump and let the cart move from rest.*

1. *Record the time ($\boldsymbol{t}$) required for the cart to traverse the indicated distances in the table below and the period time ($\boldsymbol{dt}$). Then, compute the velocity $\boldsymbol{v}$ at which the cart crossed the optical barrier.*
2. *Calculate the acceleration $\|\vec{a}\|$, and write each of them as follow: $\bar{a} \pm \Delta a$*

x	20	30	40	50	60	70	80
t(ms)							
dt(s)							
***v* (m/s)=dx/dt**							
***a* (m/s²)= v/t**							

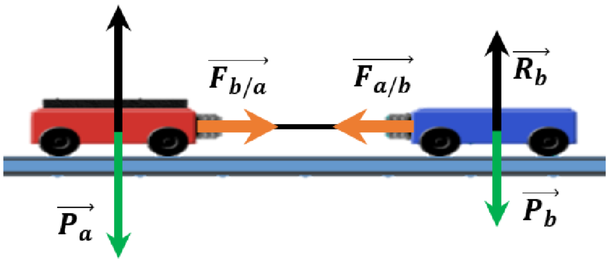
3. *Plot the curve **v =f(t).***
4. *Apply Newton's second law to find the nature of the movement of this cart.*



5. *From $\boldsymbol{v} = \boldsymbol{f}(\boldsymbol{t})$ curve, find the value of the cart's acceleration, then deduce the value of the angle of inclination of the air path. Verify by measuring the value of this angle.*

III) Experimental Verification of Newton's third Law

Place two connected carts on the edge of an air track, with a large separation distance between them, and the rubber band in a state of moderate expansion as shown in the following figure:



1. *Install the optical barrier at a distance of 10 cm from each cart. Turn on the air pump - Launch the two carts and record the time (t) it takes for each cart to reach the light barrier, as well as the period time dt for each cart (Repeat the process for the distances indicated in the table (between each cart and the optical barrier)).*

	Cart (A)				Cart (B)			
Distance (cm)	10	15	20	25	10	15	20	25
$t(s)$								
$dt(ms)$								
$v\ (m/s) == dx/dt$								

2. *Plot the curve $v = f(t)$ and plot of each cart*
3. *Calculate the acceleration of each cart*

4. *Calculate the quantities $m_a \times \|\overrightarrow{a_a}\|$ and $m_b \times \|\overrightarrow{a_b}\|$, then deduce the force applied by one cart on the other ($\|\overrightarrow{F_{a/b}}\|$ and $\|\overrightarrow{F_{b/a}}\|$)*