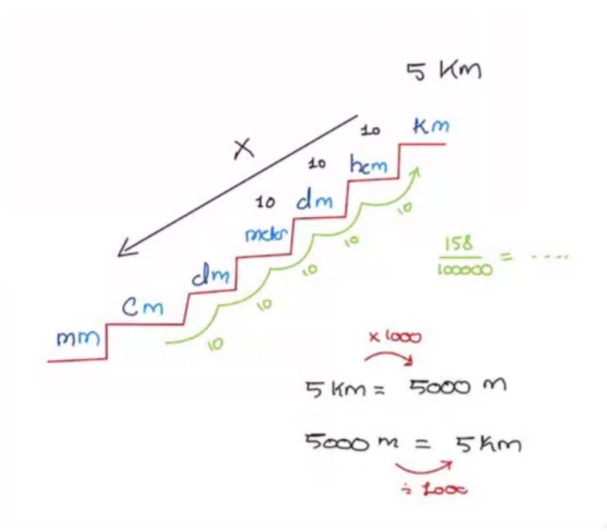
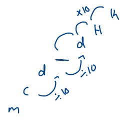
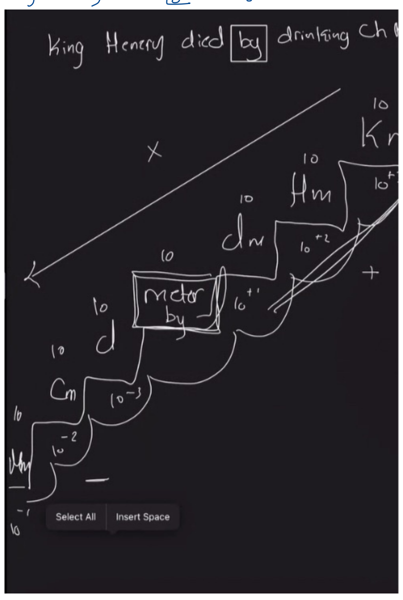
Converting





King Henry died $\boxed{\text{by}}$ drinking chocolate milk



* Relative Error = $\left| \dfrac{\text{experimental value} - \text{actual value}}{\text{actual value}} \right| \times 100 = \_\_\%$

All memorization formulas

Exp 1:

- Density = $\dfrac{\text{mass}}{\text{Volume}}$ g/cm^3
- Cylinder "v" = $\pi r^2 h$
- Sphere "v" = $\frac{4}{3}\pi r^3$

  $r = \frac{d}{2}$
- Paper "V" = L x W x Thickness
- Ruler "V" = L x W x Thickness
- Relative error = $\left| \dfrac{\text{density given} - \text{density I got}}{\text{density given}} \right| \times 100$

Exp 2:

- $y_f = y_i + v_i t - \frac{1}{2} g t^2$
- slope = $\dfrac{\Delta (t)^2}{\Delta y}$
- $g = \dfrac{2}{\text{slope}}$
- Relative error = $\left| \dfrac{9.81 - \text{gravity I got}}{9.81} \right| \times 100$

Exp 3:

- force = ma
- $F_x = f_{x_1} + f_{x_2} = f_1 \cos\theta_1 + f_2 \cos\theta_2$
- $F_y = f_{y_1} + f_{y_2} = f_1 \sin\theta_1 + f_2 \sin\theta_2$
- $F_R = |F_R| = |F_E| = \sqrt{(F_x)^2 + (F_y)^2}$
- $\theta_R = \tan^{-1}\left(\dfrac{F_y}{F_x}\right)$
- $\theta_E = \theta_R + 180$
- Relative error = $\left| \dfrac{\text{theoretical } F_R - \text{Experimental or Graphical value}}{\text{theoritical } F_R} \right| \times 100$

Exp 4:

- $V_i = \dfrac{d}{t_{gates}}$
- $t_{flight} = \sqrt{2 \cdot \frac{h}{g}}$
- $R_{calculated}$ of zero launch angle = $V_i \cdot t_{flight}$
- $R_{calculated}$ of general launch angle = $\dfrac{V_i^2}{g} \cdot \sin(2 \cdot \theta)$
- Relative error = $\left| \dfrac{R_c - R_m}{R_c} \right| \times 100$

Exp 5:

- F = ma
- Relative error = $\left| \dfrac{\text{actual value of mass} - \text{mass I found}}{\text{actual value}} \right| \times 100$

Exp 6:

- $f_s = \mu_s N$
- $N = W = mg = \left(\dfrac{\text{mass of bar} + \text{mass of box}}{1000} \right) \times 9.81$
- $\mu_s = \dfrac{f_s}{N}$
- Relative error = $\left| \dfrac{\text{actual value (given)} - \text{the coefficient of the forces}}{\text{actual value (given)}} \right| \times 100$

Exp 7:

- $\partial = \dfrac{\Delta L}{\Delta T L}$
- Relative error = Idk

Exp 8:

- $F = k \Delta x$

Exp 9:

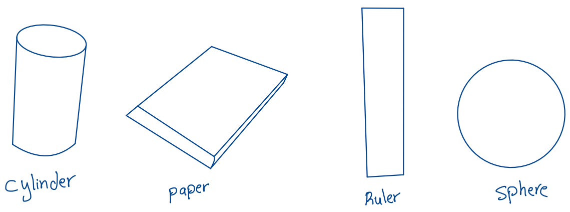
- $KE_i + PE_i = KE_f + PE_f$
- $KE = \frac{1}{2} m v^2$
- $PE = mhg$

Exp 10:

- momentum $P = mv$
- $k = \frac{1}{2} m v^2$
- $P_{total} = P_1 + P_2$
- $k_{total} = k_1 + k_2$
- percent difference of p : $\left| \dfrac{P_f - P_i}{P_i} \right| \times 100\% = \_\_\%$
- Relative error = $\dfrac{P_i - ?}{P_i} \times 100$ Idk

Experiment 1 Measurement & Error

Purpose: Using 3 different lab apparatus to measure the density of four objects

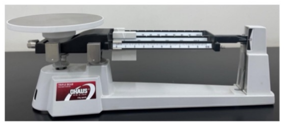


Theory:

- density (ρ) = $\frac{\text{mass (m)}}{\text{Volume (V)}}$ unit: $\frac{g}{cm^3}$
- Cylinder (V) = $\pi r^2 h$
- Sphere (V) = $\frac{4}{3}\pi r^3$
- Paper (V) = l x w x thickness
- Ruler (V) = l x w x thickness

Apparatus:

1- Triple-Bean Balance , 2- Vernier Calliper , 3- Micrometer Caliper

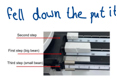


How to use it?

1- make sure every bean set to zero & the bean line match the zero

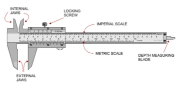
2- place the object

3- Move the bean one step forward till it fell down the put it on step back



*Until the line becomes a straight line to the zero

* To write it add them "not sure"



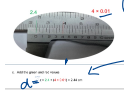
Sphere , Cylinder

How to use it?

1- place the object in the vernier caliper

2- Add the middle ruler number with third ruler

* for the middle ruler: check whats aligned with the zero of the third ruler.
* for the third rule: check for an aligned line with the middle one



fixe?

d=

3- To find the radius, divede "d" by 2

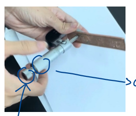
$r = \frac{d}{2}$

Paper

How to use it?

1) make its aligned with the zero

2) place the object



open it & close it from here

1 click

3) Read this one first

0 1 2 3

← it's 3

whats aligned is zero

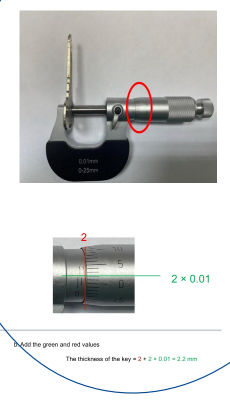
4) Thickness = $3 + (0.01 \times 0)$

fixed

So = 3 mm

5) Convert to cm

$\frac{3}{10} = 0.3$ cm



Procedure:

1- Measure the mass using the Triple Bean Balance
2- Measure the volume of ruler, sphere, and Cylinder Using Vernier caliper[Use the formulas]
3- Measure the volume of paper using micrometer caliper

Calculations:

Data and Calculations

Quantity : Unit :	Mass (g)	Dimension1 (cm)	Dimension2 : (cm)	Dimension3 : (cm)	Volume (cm^2)	Density (g/cm^2)	Relative Error (%)
Ruler Real density: …………		Length=	Width=	Thickness=	V = L× W × Th =		
Paper Real density: …………		Length=	Width=	Thickness=	V = L× W × Th =		
Cylinder Real density: …………		height=	Dimeter=	radius=	$V = \pi r^2 h$ =		
Sphere Real density: …………		-	Dimeter=	radius=	$V = \frac{4}{3}\pi r^3$ =		

→ formula for relative error:

density given density I got

$$\boxed{\frac{|\text{actual value} - \text{experimental value}|}{\text{actual value}} \times 100\%}$$

Conclusion:

we learned how to measure the densities of the objects.

Experiment 2 Free Fall

Purpose: study the relation between the displacement and time of a freely falling object & measure the acceleration of gravity

Theory: $y_f = y_i + v_i t - \frac{1}{2} g t^2$

Apparatus:

1- Drop Box , 2- Control Box , 3- Adaptor , 4- Timer switch , 5- Time of flight accessory , 6- Ball , 7- Cable , 8- Ruler, 9- Timer









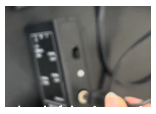
How to use it?

1 click red
3 blue
1 click black

Procedure:

1- connect the flight accessory to the timer in 2 & connect the timer switch in 1

2- connect in the other side of the timer to the control box



3- connect the adaptor to the control box

4- connect the cable to control box and drop box

5- Attach the ball to the drop box

6- Measure the height of the ball using a ruler

7- Set timer & start clicking the timer switch to drop the ball & read the time

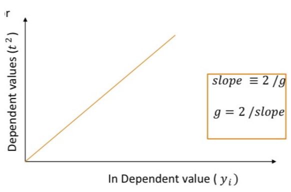
Calculations:

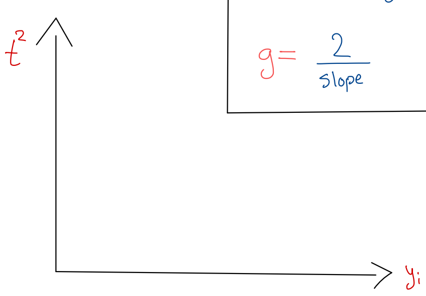
1- Table

y_i	t	t^2
80		
60		
40		
20		
0		

From Timer (t), Calculator (t^2)

2- Graph





$$\text{Slope} = \frac{\Delta (t)^2}{\Delta y}$$

$$g = \frac{2}{\text{Slope}}$$

3- Calculate the Relative error:

$$\text{Relative error} = \frac{|\text{Real Value} - \text{Experimental value}|}{\text{Real Value}} \times 100$$

9.81

gravity found

Conclusion:

we calculated the acceleration of gravity of the earth.

Experiment 3 Vectors

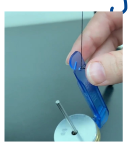
Purpose: Finding the resultant force F_R and Resultant angle θ_R and Equilibrant angle θ_e ; in 3 methods Experimentally, Graphically, and Theoretically

Theory:

- Force : $F = ma$
- Force in x-direction : $F_x = F_{x_1} + F_{x_2} = F_1 \cos\theta_1 + F_2 \cos\theta_2$
- Force in y-direction : $F_y = F_{y_1} + F_{y_2} = F_1 \sin\theta_1 + F_2 \sin\theta_2$
- Resultant force : $|F_R| = |F_e| = \sqrt{(F_x)^2 + (F_y)^2}$
- Resultant angle : $\theta_R = \tan^{-1}\left(\frac{F_y}{F_x}\right)$
  $\theta_R = \theta_e - 180$
- Equilibrant angle : $\theta_R + 180$

Apparatus:

1- Force table , 2- Mass & hanger set , 3- Protractor , 4- Graph paper , 5- pencil , 6- Ruler


Procedure :

Experimental method:

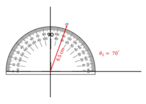
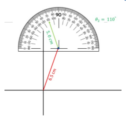
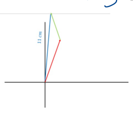
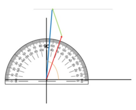
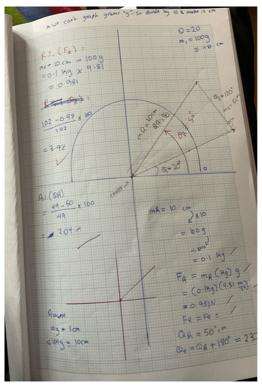
* Note : when we find m, we subtract 5

1- Add m_1 & set θ_1 in the force table
2- Add m_2 & set θ_2
3- Try different masses m_e & θ_e until the transparent ring on the force table centered
4- when you find m_e & θ_e , calculate F_R & θ_R by using :
$|F_R| = |F_e| = m_e g$ and $\theta_R = \theta_e - 180$

Graphical Method :

$$\square x \frac{1}{10g} = \square cm$$

1- m_1 & m_2 will be given in grams convert them to cm to graph
2- using the protractor draw θ_1 put a dot then using a ruler start for (0,0) a draw "m_1" line towards θ_1 direction
3- Do the same for θ_2 and m_2 , letting the 90 that is on the protractor be on the θ_1 "null sum"
4- Use the ruler to draw $m_R \longrightarrow m_R = \square \text{ cm} \times \frac{10g}{1\text{ cm}} \square g$, $|F_R| = m_R g$
5- Use the protractor to measure $\theta_R = \square^\circ$
$\theta_e = \theta_R + 180$

Theoretical Method:

	(N)	angle	X- component	Y- componant
F_1	$F_1 = m_1 * g$	70	$F_{x1} = F_1 \cos\theta_1$	$F_{y1} = F_1 \sin\theta_1$
F_2	$F_2 = m_2 * g$	110	$F_{x2} = F_2 \cos\theta_2$	$F_{y2} = F_2 \sin\theta_2$
F_3	-	-	-	-
-	-	-	$F_x = F_{x1} + F_{x2}$	$F_y = F_{y1} + F_{y2}$

$|F_R| = |F_e| = \sqrt{(F_x)^2 + (F_y)^2}$ $\theta_R = \tan^{-1}(\frac{F_y}{F_x})$ $\theta_e = \theta_R + 180$

Results :

Method	F_R (N)	θ_R	θ_e	R% of F_R	R% of θ_R	R% of θ_e
Experimental						
Graphically						
Theoretically (Real value)	1.05	87.44	267.43	-	-	-

$$\text{Relative error} = \frac{|\text{Real value} - \text{Experimental or Graphical value}|}{\text{Real value}} \times 100$$

Conclusion :

we learned how to calculate the resultant force for two forces.

Experiment 4 Projectile

Purpose: Determine the horizontal range [R] of a projectile shot for various initial velocities v_i and angles θ

Theory:

The equation of motion (2D): $\Delta distance = v_i t + \frac{1}{2} a t^2$

$\Delta y = v_{iy} t + \frac{1}{2} a_y t^2$; $\Delta x = v_{ix} t + \frac{1}{2} a_x t^2$

$\Delta y = y_f - y_i = 0 - h$ | $a_x = 0$; $\Delta x = R$; $v_{ix} = v_0$

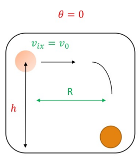
$a_y = -g$; $v_{iy} = 0$ | $R = v_0 t$

$-h = \frac{1}{2} - g t^2$

$t = \sqrt{2\frac{h}{g}}$ | $R = v_0 \sqrt{2\frac{h}{g}}$

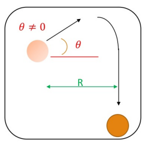
- Zero launch angle:

$* \ t = \sqrt{\frac{2 \cdot h}{g}}$ $\qquad * \ R = v_i \sqrt{\frac{2 \cdot h}{g}}$



- General launch angle:

$* \ R = \left(\frac{v_i^2}{g}\right) \sin 2\theta$



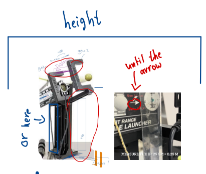
Apparatus:

1- projectile Launcher, 2- Smart Timer, 3- Two photo gate heads, 4- Metric measurement tape, 5- Carbon paper & white paper, 6- Adaptor, 7- loading Rod, 8- Steel or plastic ball, 9- Tape & Scissors

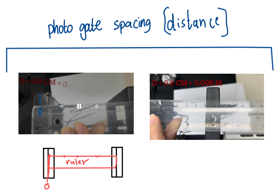
Procedure:

1- connect the two photo gates & the adaptor to the timer. "& plug the adaptor to the electricity"

2- Measure the projectile height & photo gate spacing to measure the initial velocities & flight time.



* Convert cm to m : ÷ 100

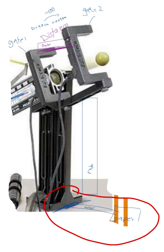


3- Insert the ball inside the projectile launcher & using the iron rod "click once" for the first time then "twice" for second ....

4- Turn on the timer & check the angle

5- pull up the string & see where the ball hit on the bench

6- Measure the horizontal Range "R" using metric measurement tape [meter]



Calculations:

1- Table

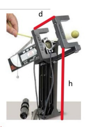
* zero launch angle:

$t = \sqrt{2\frac{h}{g}}$ $\qquad R = v_0 \sqrt{2\frac{h}{g}}$

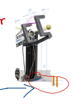
Projectile Height: h = ______ m

Photogate Spacing: d = ______ m

Range	t_{gates} (s) — Smart timer	$v_0 = \frac{d}{t_{gates}}$ (m/s)	$t_{fligh} = \sqrt{2h/g}$ (s)	$R_{calculated}$ (m)	$R_{measured}$ (m) — Ruler or meter
Short		____ ×	____ =	____	
Medium					
Long					



* Formulas:
- $V_i = \frac{d}{t_{gates}}$ ← photogate distance; t_{gates} ← timer
- $t_{flight} = \sqrt{2 \cdot \frac{h}{g}}$ ← height of the projectile; g ← 9.81
- $R_{calculated} = V_i \times t_{flight}$
- $R_{measured}$ = ruler or meter



$$\text{Relative error} = \frac{|\text{Real value } (R\ calculated) - \text{Experimental } (R\ measured)|}{\text{Real value}} \times 100$$

* General launch angle:

Photogate spacing d=

Angle θ (degrees)	t_{gates} (s) — Timer	$v_0 = \frac{d}{t_{gates}}$ (m/s)	$R_{measured}$ (m) — Ruler	$R_{calculated}$ (m) — $R = \left(\frac{v_i^2}{g}\right) sin2\theta$
25				
35				
45				
55				
65				
75				
85				

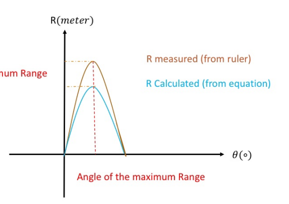
- $V_i = \frac{d}{t_{gates}}$ ← photogate distance; t_{gates} ← timer
- R_m = Ruler or meter
- $R_c = \left(\frac{V_i^2}{g}\right) \sin(2\theta)$

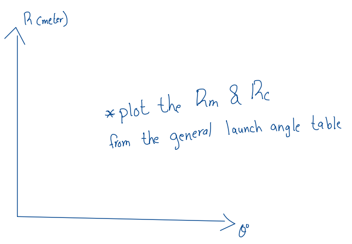
2- Graph

General Launch Angle

Plot a graph between R measured and the angle

Plot a graph between R Calculated and the angle





Conclusion:

we used one of the equations of motions to determine the horizontal range "R" of a projectile shot

Experiment 5 Newton law

Purpose: finding the mass of a car using newton second law, by studying the relationship between the acceleration of the car and the force acting on it and the carl's mass

Theory:

mass = our goal

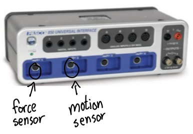
$$F = ma$$

force apply to the car, finding it by using the force sensor

acceleration of the car finding it by using the motion sensor

Apparatus:

1- force sensor, 2- dynamic system, 3- computer interface, 4- PASCAR, 5- Capstone Software, 6- Smart pulley with clamp, 7- Motion sensor, 8- Mass & hanger set & physics string




PASCO capstone

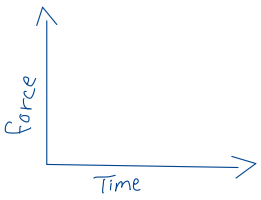

Procedure:

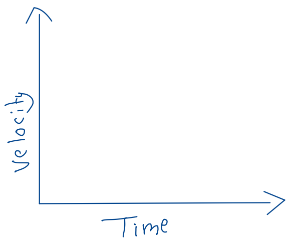
1- connect the force sensor & motion sensor to the computer interface & turn on the computer interface

2- Connect the string with the hanger to the car

3- Open Capstone Software & make sure it's connected from the hardware set up

4- Choose 2 graphs and 1 table



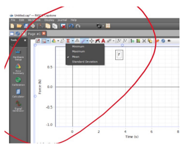
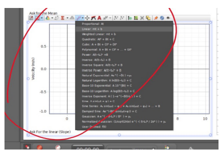


F (N)	a $(m/s)^2$

5- put the car on the middle "click run" & leave the car "click stop, before it hits the end.

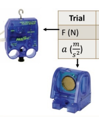
6- Then create a new page (Table & Graph) "put force & acceleration" on table & graph then take the linear

7- In force we take the mean "highlight the same time interval of velocity" & in velocity we take the linear "highlight the increasing

Calculations:

1-



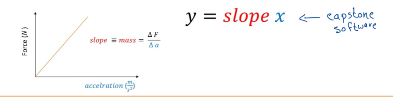
Trial	1	2	3	4	5
F (N)					
a (m/s^2)					

2-

Compare our equation with the line equation:

$F = m\,a$ ← my calculations

$y = slope\; x$ ← capstone software



3-

of the mass — of the mass

$$\text{Relative Error } R = \frac{|\text{Actual value} - \text{Experimental value}|}{\text{Actual value}} \times 100$$

Relative Error R = ... %

Note:

mass of the car + force sensor

Actual Value of the mass = ... kg

Conclusion:

we found the mass of the car using newton second law

Experiment 6 Friction Force

Purpose: 1- find the coefficient of static friction μ_s & kinetic friction μ_k

Theory:

* Applying a force to an object & the object is not moving until we arrive to the static fractional force

$$f_s = \mu_s N$$

f_s → static fractional force

N ← Normal force, $N = W = mg$

coefficient of static friction $\mu_s = \frac{f_s}{N}$

* Applying a force to an object and the object is moving in same speed all the time (acceleration = 0)

$$f_k = \mu_k N$$

f_k → kinetic fractional force

N → Normal force, $N = W = mg$

coefficient of kinetic friction $\mu_k = \frac{f_k}{N}$

Apparatus:

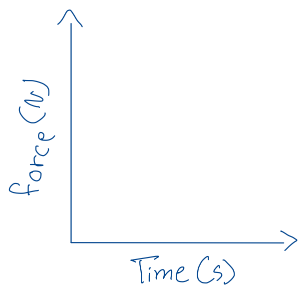
1- Force sensor, 2- Computer Interface, 3- Triple bean balance, 4- Friction Accessory & String, 5- Capstone Software, 6- Motion Sensor, 7- Bar masses

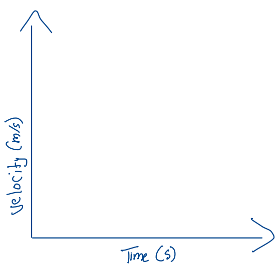
Procedure:

1- Connect the force sensor with the friction accessory. Face the motion sensor to the Friction Accessory.

2- Connect the motion and force sensors with the interface

3- Open the PASCO software and choose two graphs and table





f_s (N)	f_k (N)	N (N)

← normal force: $N = m * g$

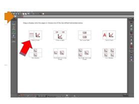
4- If it has negative values → change the sign to positive

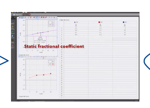
5- highlight from a certain time to time in both graphs [not sure]

6- f_s is the graph with force (N) / time (s) "Take the max"

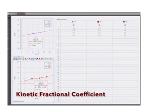
7- f_k is the graph with velocity (m/s) / time (s) "Take the mean"

8- Open a new page choose Table & Graph and add a column





Finding the coefficient from the linear (slope)



← call your data

Calculations:

1- Calculate the normal force (N) from the begining

$N = mxg = \left(\frac{500g + \text{mass of box in g}}{1000}\right) kg \times 9.81$	← for one bar
$= \left(\frac{1000 + \text{mass of box}}{1000}\right) \times 9.81$	← for two bars
$= \left(\frac{1500 + \text{mass of box}}{1000}\right) \times 9.81$	← for three bars
$= \left(\frac{2000 + \text{mass of box}}{1000}\right) \times 9.81$	← for four bars

2- Find the relative error of { μ_s, μ_k } →

$$\text{Relative Error } R = \frac{|\text{Actual value} - \text{Experimental value}|}{\text{Actual value}} \times 100$$

(Actual value: given; Experimental value: the coefficient of the forces)

Relative Error R = ... %

→ The relative error of μ_s = ——— %

The relative error of μ_k = ——— %

Conclusion:

we calculated the static fractional force & kinetic fractional force

Experiment 7 Thermal Expansion

Purpose: find thermal expansion coefficient

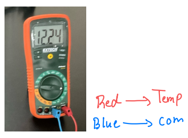
Theory: $\alpha = \frac{\Delta L}{\Delta T L}$

- α: Thermal expansion coefficient
- ΔL: increase in the length of the tube in mm
- L: length of the tube
- ΔT: Difference in temperature

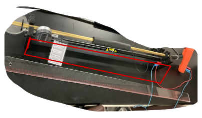
Apparatus:

1- Metal tube, 2- Steam generator & water, 3- Ruler, 4- Ohm's meter & wires, 5- Thermostat and dial gauge



Procedure:

1- measure the length of the tube from middle "ring" black to black


2- Turn on the dial gauge & zero it out


3- Connect the multimeter "Ohm's meter" Red & blue wire [Red right, blue left] (Red up, blue down)

4- Turn the dial from off to 20 kOHM

5- Black wire from tube connect it to first hole

6- Insert steam generator to tube

7- The number you see in multimeter convert it from RM to kohm by multiplying by 1000 = ____ ohm (not sure)

8- Then search the closest number $\boxed{T_{rm}}$ in the table given

9- wait for stem "smoke" then take the number, it will be R_{hot} then search for T_{hot} in the table

10- ΔL is the dial gauge

Calculations:

$\alpha = \frac{\Delta L}{\Delta T L}$ (Thermal)

Unit: $\frac{1}{C^\circ}$

1-

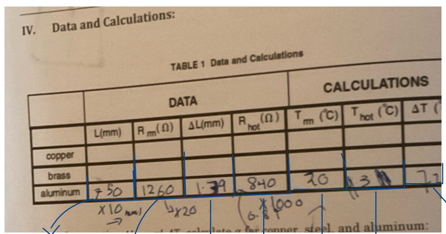
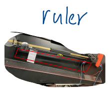

IV. Data and Calculations:

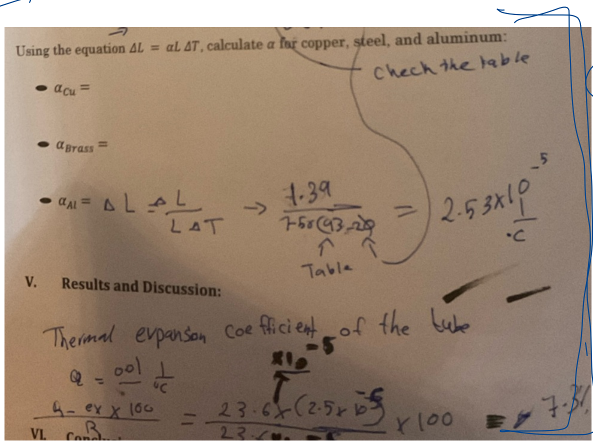
TABLE 1 Data and Calculations

	DATA				CALCULATIONS		
	L(mm)	R_{rm}(Ω)	ΔL(mm)	R_{hot}(Ω)	T_{rm} (°C)	T_{hot} (°C)	ΔT (°C)
copper							
brass							
aluminum	750	1260	1.39	840	20	93	73

$\times 10$ mm, $\times 20$, $\times 1000$

- L: ruler
- R_{rm}: from reading the ohm's meter, R_{rm} = reading $\times 10^3$
- ΔL: from the gauge, after steam
- R_{hot}: reading the ohm's meter after the steam
- T_{rm}: search for the Rm in the table
- T_{hot}: Search for Rhot from the table
- ΔT: $T_{hot} - T_{rm}$




Using the equation $\Delta L = \alpha L \Delta T$, calculate α for copper, steel, and aluminum:

- α_{Cu} =
- α_{Brass} =
- $\alpha_{Al} = \Delta L = \frac{\Delta L}{L \Delta T} \rightarrow \frac{1.39}{750(93-20)} = 2.53 \times 10^{-5} \frac{1}{°C}$ (Table) Check the table

V. Results and Discussion:

Thermal expansion coefficient of the tube

$\alpha = .001 \frac{1}{°C}$

$\frac{A - ex \times 100}{B} = \frac{23.6 \times 10^{-5} - (2.5 \times 10^{-5})}{23.6 \times 10^{-5}} \times 100 = 7.3\%$

VI. Conclusion

2- Substitute:

$\alpha = \frac{\Delta L}{L \Delta T} = \square \ \frac{1}{C^\circ}$

¿ ? not sure

3- Find the relative error:

$$\text{Relative Error } R = \frac{|\text{Actual value} - \text{Experimental value}|}{\text{Actual value}} \times 100$$

Relative Error R = ... %

Conclusion:

we found the thermal expansion coefficient

Experiment 8 Spring

Purpose: find the spring constant k

Theory: $F = k \Delta x$

force — spring constant — spring displacement

Apparatus:

1- Force sensor, 2- Capstone Software, 3- Computer interface, 4- Clamp, 5- Ruler, 6- Five Springs

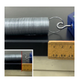
PASCO capstone

Procedure:

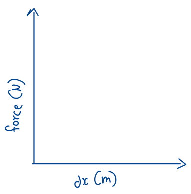
1- connect the spring with the clamp 

2- connect the spring with the force sensor 

3- connect the force sensor with interface 

4- fix the ruler on the bench 

5- Open Pasco Software and choose graph & table



Force (N)	dx (m)

insert the values you will expand the spring 10 cm at a time = 0.1 meter

0.1
0.2
0.3
0.4
0.5

* Expanding : expand the spring 10 cm at a time [each time you expand it press (keep on) on the software & find the (spring constant k) from the (slope)

* Compressing : Insert the values of dx you will compress the spring 0.5 cm at a time = 0.005 meter "The opposite of expanding" "In compressing, change the ruler position"

Set dx (m)
0.005
0.010
0.015
0.020
0.025

Conclusion:

we found the spring constant for five different springs

Experiment 9 Conservation of Energy

* Simillar to free fall

Purpose: Approve that energy is conserved

Theory:

$$\cdot KE_i + PE_i = KE_f + PE_f$$

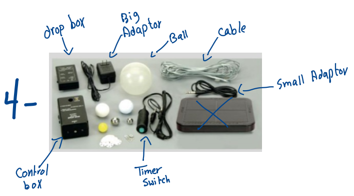
$$\cdot KE = \frac{1}{2} mv^2$$

$$\cdot PE = mhg$$

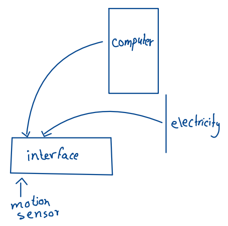
Apparatus:

1- Capstone Software, 2- Motion sensor, 3- Pasport interface 4-

PASCO capstone



Procedure:



1- connect the interface to the computer & to the electricity using the adaptor

2- Connect the motion sensor to the interface

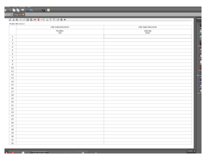
3- Using the cable, connect the drop box & control box together

4- Connect the timer switch to the control box & interface

5- Attach the ball

6- Open PASCO software & choose graph and table

Position (m)	Velocity (m/s)



7- press start in the software then press the green button on the timer switch

8- Read the height & velocity of the ball from the software

Calculations:

software ↓ software ↓ $U = mgh$ ↓ $K = \frac{1}{2}mv^2$ ↓ $\overset{U}{PE + KE}$ ↓

	H (m)	V (m/s)	PE (J)	KE (J)	E (J)
Initial h					
¾ h					
½ h					
¼ h					

* Don't forget to convert $g \xrightarrow{\div 100} kg$

Conclusion:

The total energy of the closed system is conserved

Experiment 10 Conservation of Momentum

Purpose: Investigate the conservation of momentum and kinetic energy

4 situations → Elastic (equal masses); elastic (non-equal masses); nonelastic (equal masses); non-elastic (not equal masses)

Theory:

- Momentum: $\vec{P} = m \times \vec{v}$
- Kinetic energy: $KE = \frac{1}{2}mv^2$
- law of conservation of momentum: $\vec{P}_{\text{total before collision}} = \vec{P}_{\text{Total After collision}}$

Apparatus:

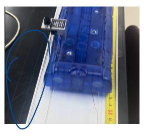
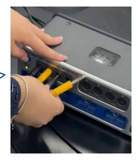
1- Mass Balance, 2- 1.2 Dynamic Track, 3- Computer interface, 4- Two PAS cars, 5- Capstone software, 6- Smart pully with clamp, 7- 250g Mass Bars, 8- Rotary Motion Sensor ↑






Procedure:

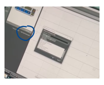
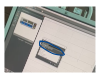
1- Take the string of the blue car & connect it to "1" and "2" in the interface then do the same on the other car and connect it in "3" and "4"

 →  → 

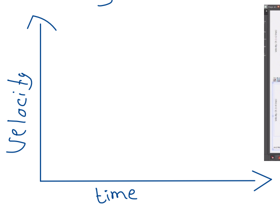
2- Connect the interface to the computer & connect the rotary motion sensor to the interface

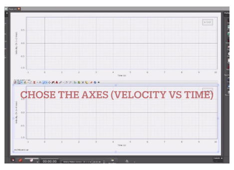
3- Open capstone software → Choose 2 graphs → make sure the cars are connected in the software → Hardware Set up → add sensor → Digital sensors → Rotary Motion Sensor

Do this for both cars


4- Choose Velocity & time



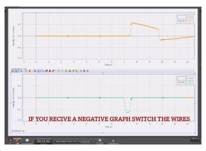


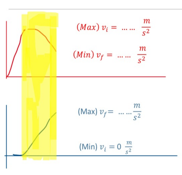
✱ Inelastic Collision [equal masses] "black faces black"

1- Use the same mass car with the "black towards each other"
2- Car 2 is at rest, press the "start" and push cart 1 towards cart 2 then click stop
3- In the graph, highlight the velocity of cart 1 just before and after the collision ← ? كيف
4- Do the calculations, then calculate the percent difference

→ ✱ Ask for maximum & minimum velocities

✱ Exchange yellow & black gates



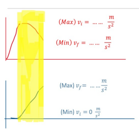


moving car, highlight the decreasing

stable car, highlight the increasing

✱ Inelastic Collision [unequal masses] "black faces black"

"Same just change the mass"

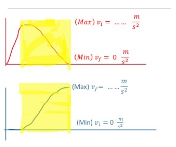


moving = decreasing

stable = increasing

✱ Elastic Collision [equal masses]

"Same but don't let the (blacks face each other)

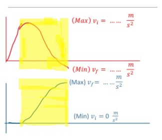


moving = decreasing

stable = increasing

✱ Elastic Collision [unequal masses]

"Same as this, just change the mass"



moving = decreasing

stable = increasing

Calculations:

1- This Table for all 4 situations

Part 2A : Equal masses
$m_1 = m_2 = \ldots\ldots\ldots\ldots (kg)$

mv $\quad \frac{1}{2}mv^2$ $\quad P_1+P_2$ $\quad K_1+K_2$

	Cart 1			Cart 2				
	v_1 (m/s)	P_1 (kg·m/s)	K_1 (J)	v_2 (m/s)	P_2 (kg·m/s)	K_2 (J)	Total P	Total K
Before (Initial)			+			=		
After (Final)								

* Velocity from the graph ← ?τ°

* P = mass x velocity = mv

* $K = \frac{1}{2}mv^2$

* $P_{Total} = P_1 + P_2$

* $K_{total} = K_1 + K_2$

2- The percent difference of P

$$\frac{|P_f - P_i|}{P_i} \times 100\% = \_\_\_\_ \%$$

Part 2A : Equal masses
$m_1 = m_2 = \ldots\ldots\ldots\ldots (kg)$

mv $\quad \frac{1}{2}mv^2$ $\quad P_1+P_2$ $\quad K_1+K_2$

	Cart 1			Cart 2				
	v_1 (m/s)	P_1 (kg·m/s)	K_1 (J)	v_2 (m/s)	P_2 (kg·m/s)	K_2 (J)	Total P	Total K
Before (Initial)			+			=		
After (Final)								

IDK

P_i ?

$$Relative\ Error\ R = \frac{|\text{Actual value} - \text{Experimental value}|}{\text{Actual value}} \times 100$$

$Relative\ Error\ R = \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ \%$

Discussion:

All are conserved except the kinetic energy of a system in Inelastic collision is not conserved

Conclusion:

The momentum of a system in INELASTIC and ELASTIC collisions is conserved.