Umm Al-Qura University

College of Applied Science

Physics Department

Physics (2)

For Engineering

Experiment 1

Levers

University ID Number: ………………..………………………

Group Number: ……………………………………………

- **Objectives**:

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- **Apparatus**:

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- **Theory**:

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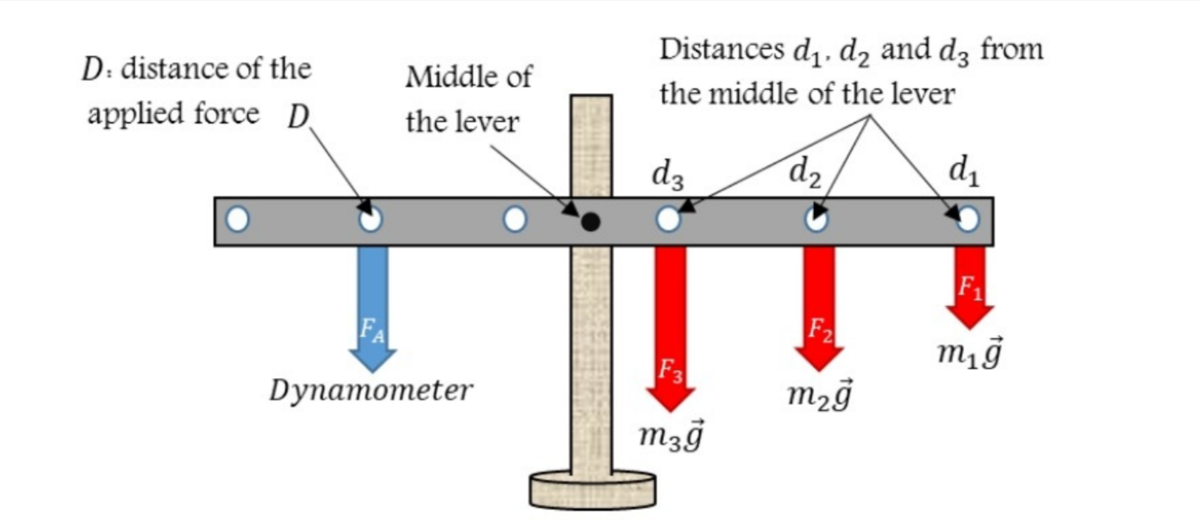

D: distance of the applied force D
Middle of the lever
Distances d_1. d_2 and d_3 from the middle of the lever
d_3
d_2
d_1
F_A
Dynamometer
F_3
$m_3\vec{g}$
F_2
$m_2\vec{g}$
F_1
$m_1\vec{g}$

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left side of the lever			right side of the lever								
F (N)	D (m)	τ_A (N.m)	m_1 (kg)	d_1 (m)	τ_1 (N.m)	m_2 (kg)	d_2 (m)	τ_2 (N.m)	m_3 (kg)	d_3 (m)	τ_3 (N.m)
1.0	0.40	0.40	0.090	0.48	0.432	0.105	0.40	0.42	0.136	0.32	0.416
1.2		0.48	0.105		0.504	0.125		0.50	0.160		0.512
1.4		0.55	0.125		0.606	0.160		0.64	0.180		0.576
1.6		0.64	0.140		0.672	0.165		0.66	0.210		0.672
1.8		0.72	0.155		0.744	0.190		0.76	0.335		0.752

عكس τ_1 — t_{avg} — الانحراف

τ_{ccw}	τ_{cw}	$\Delta\tau$	error% $\frac{\Delta\tau}{\tau_{cw}} \times 100$
0.4	0.422	0.022	5.2
0.48	0.505	0.025	4.9
0.56	0.605	0.045	7.4
0.64	0.688	0.028	4.1
0.72	0.752	6.032	4.2

Conclusion

$\tau_{ccw} \approx \tau_{cw}$

the value of $\Delta\tau$ is very small and there is little error

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Physics (2)

For Engineering

Experiment 2

Archimedes' Law

University ID Number: …………………..……………………………

Group Number: ……………………………………………………………

- **Objectives**:

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- **Apparatus**:

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- **Theory**:

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- **procedures**:

Part.1. Measuring the displacement fluid density:

The length of the rectangular cuboid =....6......cm=..0.06...m

The width of the rectangular cuboid =...2......cm=..0.02....m

F_1 (N)	h (m)	F_2 (N)	F_b (N)
	0.02	1.2	0.22
	0.04	0.9	0.52
	0.06	0.65	0.77
	0.08	0.4	1.02
	0.10	0.2	1.22

By plotting F_b versus h the slop (m) =...12.5 N/m........................

Calculating the displacement fluid density ρ_d:

Used equation:

$$\rho_d = \frac{slope}{w \times d \times g}$$

The value of the displacement fluid density ρ_d:

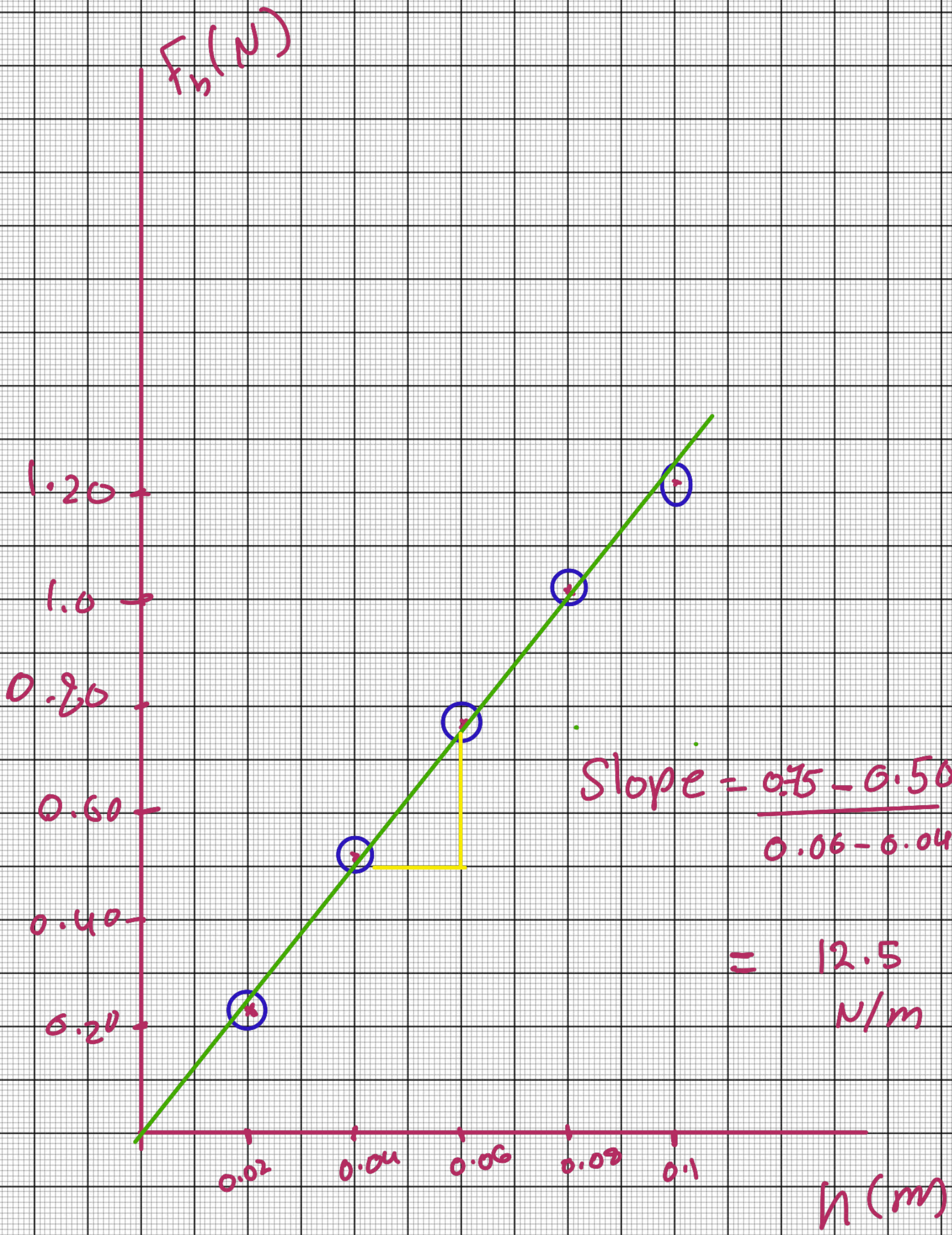
$$\rho = \frac{12.5}{0.02 \times 0.06 \times 9.8} = 1062 \ kg/m^3$$

Calculating the percentage error:

If the theoretical value of the fluid density $\rho_d = 997 \ kg/m^3$, the percentage error value in ρ_d:

$$error\ \% = \frac{|\rho_{thor} - \rho_{exp}|}{\rho_{the}} = \left|\frac{1062 - 997}{997}\right| \times 100$$

$$= 6.5\ \%$$



$$\text{Slope} = \frac{0.75 - 0.50}{0.06 - 0.04}$$

$$= 12.5 \text{ N/m}$$

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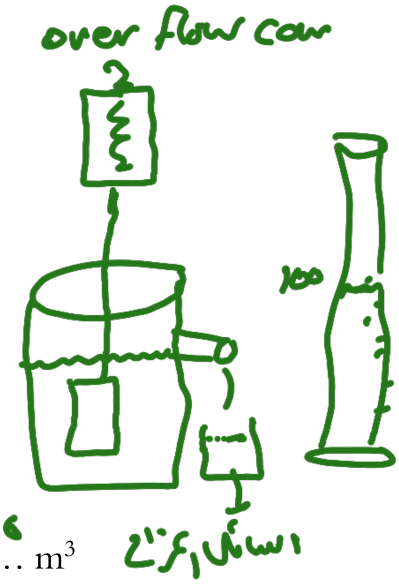

Part.2. Checking Archimedes' law:

الوزن في الهواء

The weight of the cuboid in air F_1=……1.5……N

الوزن في الماء

The weight of the cuboid in water F_2=……0.4……N

السائل غ.م

The deduced fluid density ρ_d in part 1=……1062……kg/m³

حجم السائل المزاح

the volume of the displaced water V_d=……100…… cm³=……100×10^{-6}…… m³

طريقة ①

Calculating the buoyant force F_b using equation (3.1):

Used equation: قوة الطفو = كثافة السائل × حجم السائل المزاح × g

$$F_b = \rho_d V_d g$$

The value of the buoyant force F_b:

$$F_b = 1062 \times 100\times10^{-6} \times 9.8 = 1.04\ N$$

طريقة ②

Calculating the buoyant force F_b using equation (3.2):

Used equation: قوة الطفو = الوزن في الهواء − الوزن في الماء

$$F_b = F_1 - F_2$$

The value of the buoyant force F_b:

$$F_b = 1.5 - 0.4 = 1.1\ N$$

Calculating the percentage difference between the two calculated values of buoyant force F_b: الفرق النسبي بين قيمتين = |الفرق بين القيمتين| / متوسط القيمتين

Used equation:

$$P.D = \frac{F_{b1} - F_{b2}}{\frac{F_{b1}+F_{b2}}{2}} \times 100\%$$

The value of the percentage difference P. D.:

$$= \left| \frac{1.04 - 1.1}{\frac{1.04+1.1}{2}} \right| \times 100\% = 5.6\%$$

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Physics (2)

For Engineering

Experiment 3

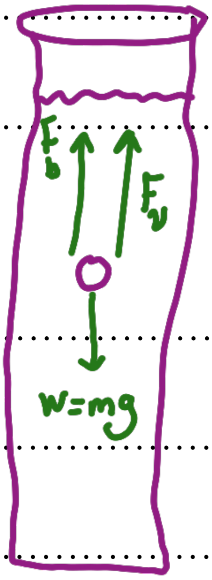
Viscosity اللزوجة

University ID Number: ……………………………………………

Group Number: …………………………………………………

- **Objectives**:

- ~~**Apparatus**~~:



حالة الاتزان

$$F_B + F_v = F_g$$

- ~~**Theory**~~:

$$F_g = mg = \rho_b V_b g = \rho_b \frac{4}{3}\pi r^3 g$$

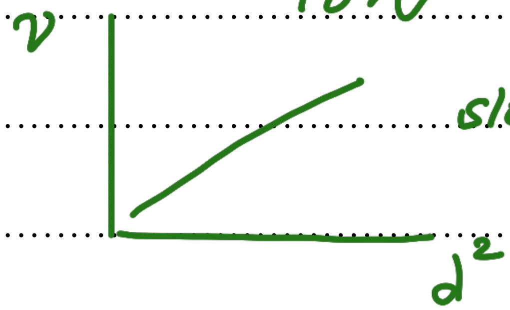
$$F_B = \rho_d V_b g = \rho_d \frac{4}{3}\pi r^3 g$$

$$F_v = 6\pi r \eta v$$

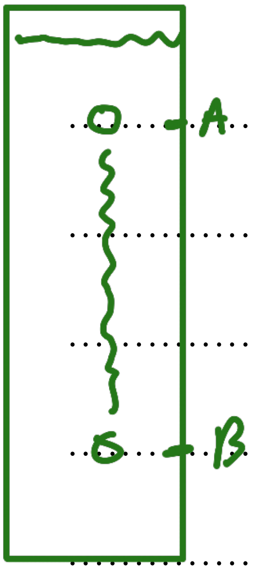
الهدف حساب معامل اللزوجة

d قطر الكرة التي نرميها في السائل

$$v = \frac{g(\rho_b - \rho_d) d^2}{18\eta}$$



$$slope = \frac{g(\rho_b - \rho_d)}{18\eta}$$



① تحديد المسافة $A \to B$

$d = 50cm$

② نستخدم مجهر صغير لقياس قطر الكرة $\ominus$

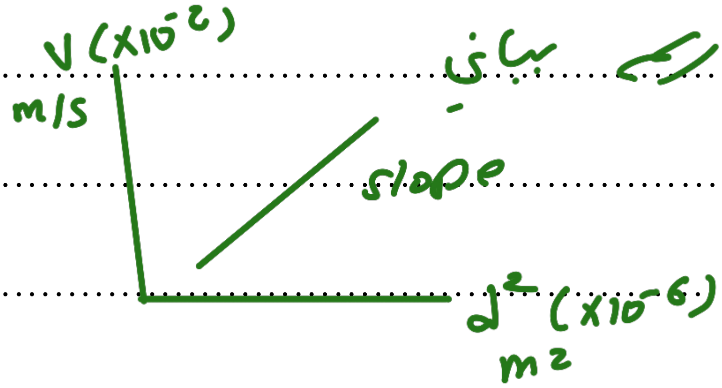
③ نرمي الكرة في السائل ونحسب الزمن اللازم للعبور من $A \to B$ Δt

④ نحسب السرعة $v = \dfrac{d}{\Delta t}$

اذا كانت $50cm$ $\Delta t = 10s$ $v = \frac{50}{10} = 5cm/s$

⑤ نعيد نفس الخطوات السابقة باستخدام كرات مختلفة ونلاحظ الحلول

⑥ نرسم رسم بياني



⑦ $$\eta_{exp} = \frac{g(\rho_b - \rho_d)}{18 \times slope}$$

$\rho_b = 7870\ kg/m^3$ $\rho_d = 1260\ kg/m^2$

$\eta_{thor} = 1.5\ Pa.s$

- **procedures**:

The distance between point A and B=...50.....cm=...0.5....m

d (mm)	d $\times 10^{-3}$ (m)	d^2 (m^2)	Δt (s)	v (m/s)
3	3×10^{-3}	9×10^{-6}	10	$\frac{0.5}{10}=0.05=5\times10^{-2}$
4	4×10^{-3}	16×10^{-6}	7	$\frac{0.5}{7}=0.071=7.1\times10^{-2}$
5	5×10^{-3}	25×10^{-6}	5	$\frac{0.5}{5}=0.10=10\times10^{-2}$

By plotting v versus d^2 the slop (m) =........3076...............

Calculating the viscosity of glycerol η:

Used equation:

$$\eta = \frac{g(\rho_b-\rho_d)}{18\times slope} = \frac{9.8(7870-1260)}{18\times 3076} = 1.2\ Pa.s$$

Known parameters:

Density of the ball: $\rho_b = 7870\ kg/m^3$

Density of the displaced fluid: $\rho_d = 1260\ kg/m^3$

Acceleration due to gravity: $g = 9.80\ m/s^2$.

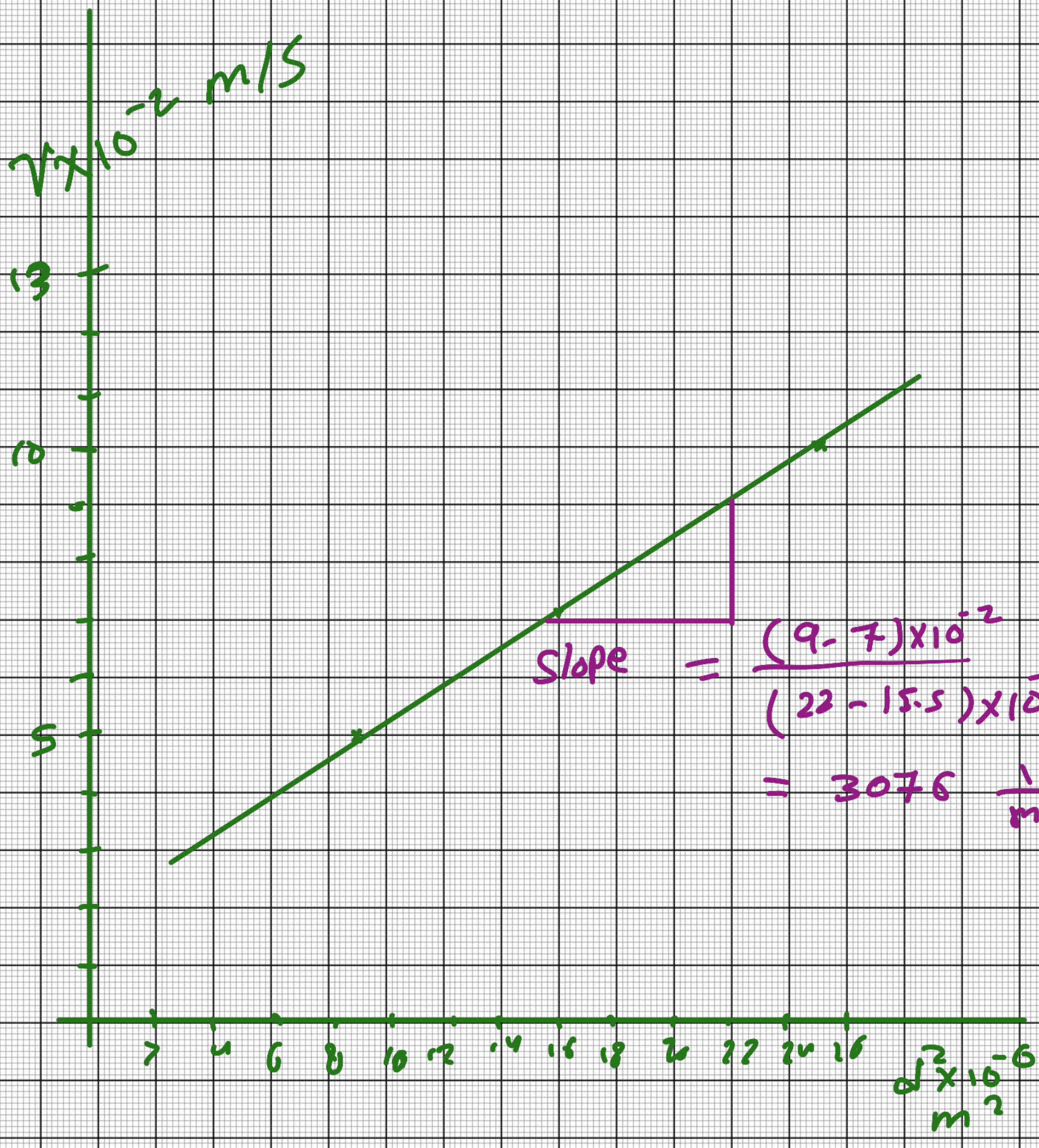
The value of the viscosity of glycerol η:

..........1.2 Pa.s..........

Calculating the percentage error:

If the theoretical value of the viscosity at 20°C is $\eta_{th} = 1.5$ Pa. s, the percentage error value in η_{exp}:

$$P.E = \left|\frac{\eta_{theo}-\eta_{exp}}{\eta_{theo}}\right| = \left|\frac{1.5-1.2}{1.5}\right| \times 100\%$$



$$\text{Slope} = \frac{(9-7)\times 10^{-2}}{(22-15.5)\times 10^{-6}} = 3076\ \frac{1}{ms}$$

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Physics (2)

For Engineering

Experiment 4

Conservation of Linear Momentum in

حفظ الزخم الخطي

Collisions

التصادمات

University ID Number: ……………………………………………

Group Number: ……………………………………………………

- **Objectives**:

$P = mv$ kg m/s

قانون حفظ الزخم ← مجموع الزخم قبل التصادم = مجموع الزخم بعد التصادم

- **Apparatus**:

انواع التصادمات

- **Theory**:

Elastic (مرن)

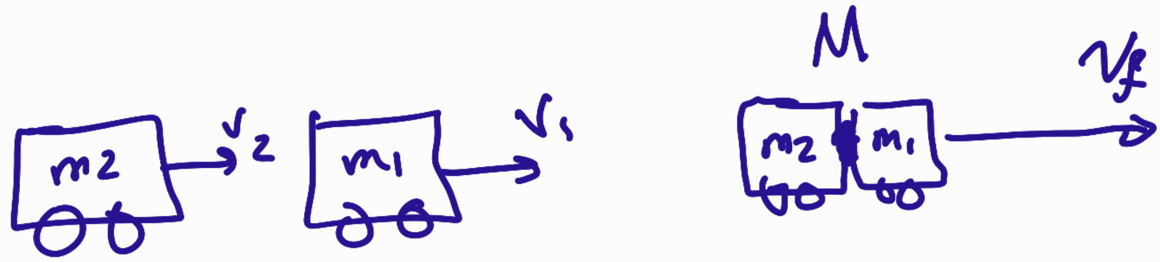
$\Sigma P_i = m_1 v_{1i} + m_2 v_{2i}$ مجموع الزخم قبل

$\Sigma P_f = m_1 v_{1f} + m_2 v_{2f}$

$$m_1 v_{1i} + m_2 v_{2i} = m_1 v_{1f} + m_2 v_{2f}$$

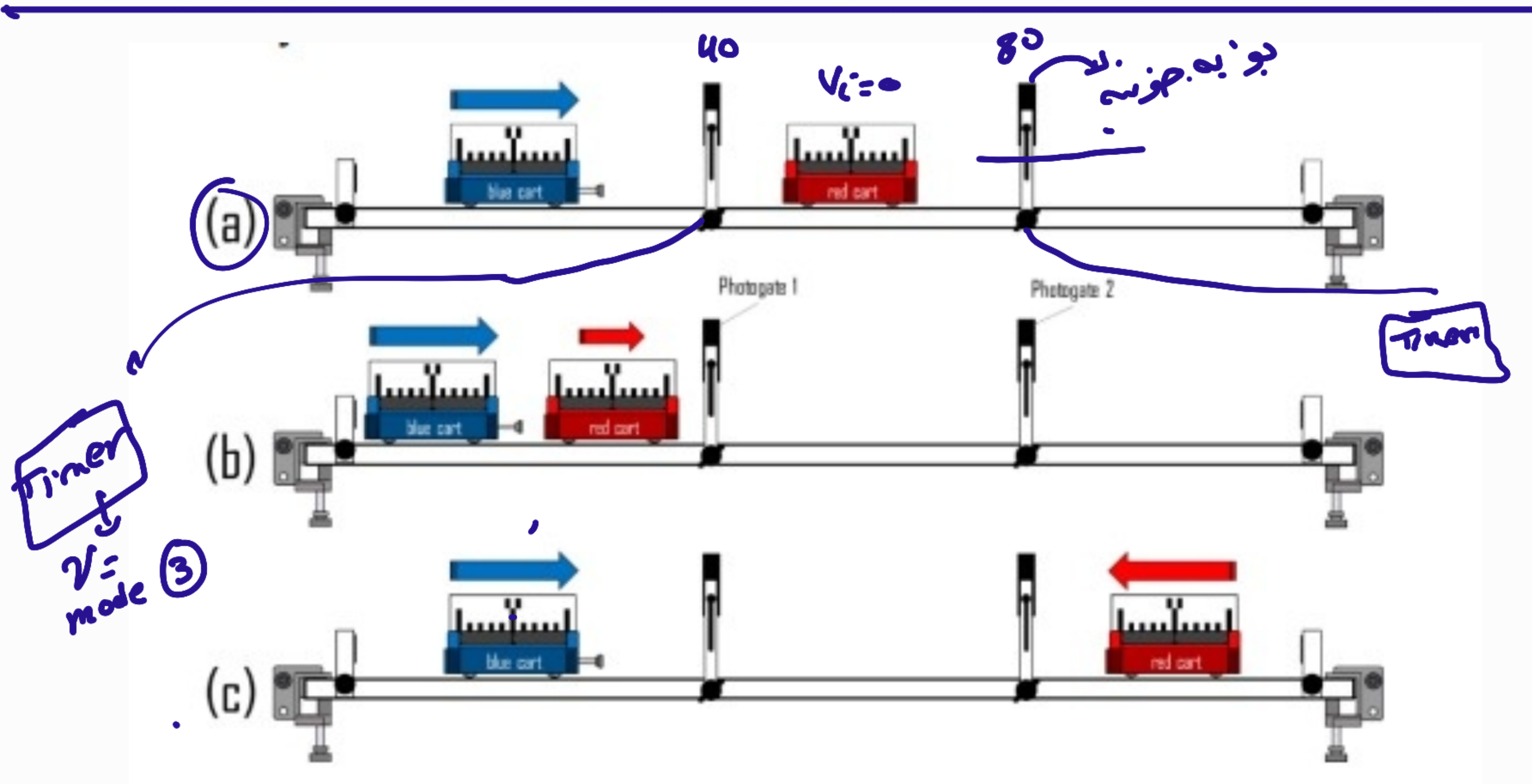
Inelastic غير مرن

يلتحم الجسمين معاً بعد التصادم ويتحركان بسرعة واحدة



الزخم قبل = الزخم بعد

$$m_1 v_1 + m_2 v_2 = (m_1 + m_2) v_f$$



الجزء ① التصادم المرن ⓐ

① نضع العربة الحمراء بين البوابتين والزرقاء على اليسار والعربة الحمراء ساكنة وننطلق العربة الزرقاء

② نكرر الخطوة لكتلة مختلفة من الربات

③ نحسب مجموع الزخم قبل و بعد

$P_i = m_1 v_{1i} + m_2 v_{2i}$

$P_f = m_1 v_f + m_2 v_f$

case		blue cart			red cart		momentum		
	m_1 (kg)	before	after	m_2 (kg)	before	after	before	after	P.D.
		v_{1i} (m/s)	v_{1f} (m/s)		v_{2i} (m/s)	v_{2f} (m/s)	P_i $(kg.\frac{m}{s})$	P_f $(kg.\frac{m}{s})$	
(a) One at rest	0.50	بوابه	2 بوابه	1.00	0	2 بوابه	قبل	بعد	
	0.75	70	0	0.75	0	71	52.5	53.25	1.4
(b) Both moving	1.00	25	23	0.50	10	16	30	31	3.2
	0.75			0.75					
Head to head	0.50	40	-35	1.00	-10	28	10	10.5	
	0.75			0.75					

$P_i = 0.75 \times 70 + 0.75 \times 0 = 52.5$ kgm/s

$P_f = 0.75 \times 0 + 0.75 \times 71 = 53.25$ kgm/s

P.D (a)

$$\frac{\left| \text{القيمة الاولى} - \text{القيمة الثانية} \right|}{\frac{\text{القيمة الاولى} + \text{الثانية}}{2}} \times 100\%$$

$$\frac{\left| 53.25 - 52.5 \right|}{\frac{53.25 + 52.5}{2}} \times 100\% = 1.4\%$$

(b) السيارتين متحركتين

نضع السيارتين على مسار البوابات والحمراء

نعطيها سرعة اقل من الزرقاء بحيث

يحدث التصادم بين البوابات

ونحدد كل الخطوات السابقة كتجربتين مختلفتين

Head to head (c)

تصادم رأسي

عند وضع مقدار السرعه يجب الانتباه للاشارات

توضع السيارتين على اطراف المدرج الهوائي ويتم اطلاقهم بشكل متقابل ونعيد جميع الخطوات السابقة.

Part 2

Inelastic collision

كلا العربتين

case	blue cart		red cart		both	momentum		
		before		before	after	before	after	
	m_1 (kg)	v_{1i} (m/s)	m_2 (kg)	v_{2i} (m/s)	v_f (m/s)	P_i $(kg.\frac{m}{s})$	P_f $(kg.\frac{m}{s})$	P.D.
One at rest	1.00	65	0.5	0	47	65	70.5	
	0.75		0.75	0				
Both moving	0.50		1.00					
	0.75		0.75					
Head to head	1.00		0.50					
	0.5		1.00					

$P_i = m_1 v_{1i} + m_2 v_{2i} = 65(1) + 0.5(0) = 65$

$P_f = (m_1 + m_2) v_f = (1 + 0.5)\, 47 = 70.5$

كل الخطوات الباقية نفسها

- **procedures**:

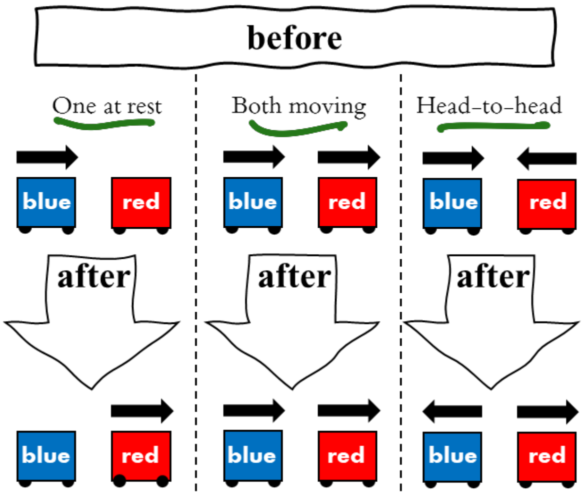
Part.1. Elastic collision:

The equation used for calculating the momentum (P):

$P_i = m_1 v_{1i} + m_2 v_{2i}$ ....

$P_f = m_1 v_{1f} + m_2 v_{2f}$ ....

....



case	*blue* cart			*red* cart			*momentum*		
	m_1 (kg)	*before* v_{1i} (m/s)	*after* v_{1f} (m/s)	m_2 (kg)	*before* v_{2i} (m/s)	*after* v_{2f} (m/s)	*before* P_i $(kg.\frac{m}{s})$	*after* P_f $(kg.\frac{m}{s})$	$P.D.$
One at rest	0.50			1.00	0				
	0.75			0.75	0				
Both moving	1.00			0.50					
	0.75			0.75					
Head to head	0.50			1.00					
	0.75			0.75					

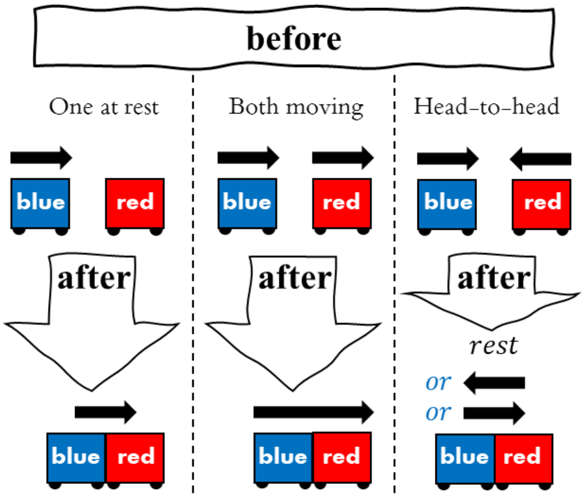
Observations:

....

the momentum is conserved

because P_f x P_i

Part.2. Inelastic collision:



The equation used for calculating the momentum (P):

$P_i = m_1 v_{1i} + m_2 v_{2i}$ ....

$P_f = (m_1 + m_2) v_f$ ....

....

case	blue cart		red cart		both	momentum		
		before		before	after	before	after	
	m_1 (kg)	v_{1i} (m/s)	m_2 (kg)	v_{2i} (m/s)	v_f (m/s)	P_i $(kg.\frac{m}{s})$	P_f $(kg.\frac{m}{s})$	$P.D.$
One at rest	1.00		0.5	0				
	0.75		0.75	0				
Both moving	0.50		1.00					
	0.75		0.75					
Head to head	1.00		0.50					
	0.5		1.00					

Observations:

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....

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Physics (2)

For Engineering

Experiment 5

Moment of Inertia

University ID Number: ………………..…………………………

Group Number: …………………………………………………

- **Objectives**:

Inertia = I

$I = \frac{2}{5}MR^2$

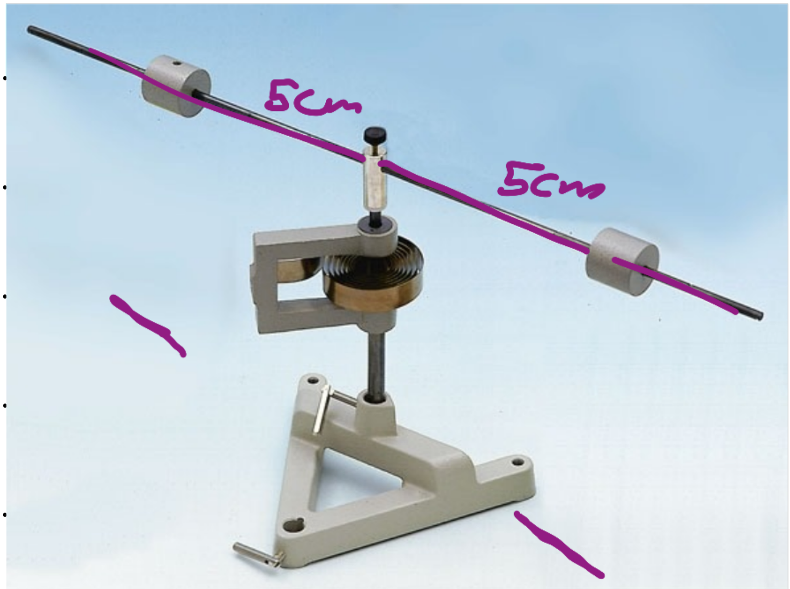
$I = \frac{ML^2}{3}$

- **Apparatus**:

torsion axle

اداة نستخدم لحساب I لاي جسم كان

- **Theory**:



منحسب I شكلة فقط اي

T: period of oscillation

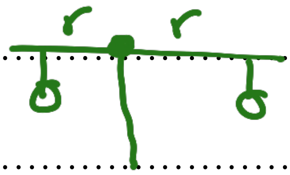
$$I = \tau\left(\frac{T}{2\pi}\right)^2$$

الهدف الاول من التجربة هو حساب τ

τ: restoring torque

عند استخدام قضيب فقط دون وزنات

$$I_0 = t\left(\frac{T_0}{2\pi}\right)^2$$



مع وجود الوزنات

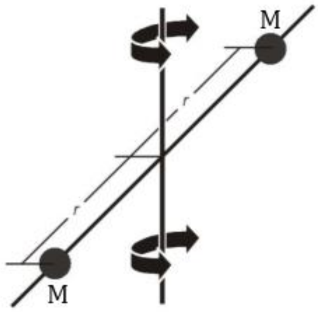
$$I = 2mr^2 + I_0$$

$$T^2 = \frac{8\pi^2 m r^2}{t} + T_0^2$$

خطوات التجربة (العلاقة بين r و T)

1. نثبت القضيب على منتصف محور الدوران ونركب الكتل على مسافة 5cm من المحور
2. نعيد تحديد موضع الاتزان على الطاولة نزور 180°
3. نبدأ بعد 5 اهتزازات ونسجل زمنها باستخدام ساعة توقيت (t) $N=5$
4. نكرر العملية أكثر من مرة باستخدام (r) مختلفة ونملأ الجدول

- **procedures**:



Part1: – Deducing Restoring Torque τ :

The mass put on the rod m =236 g= 0.236 kg m

Equation used for calculating the period (T):

.... $T = \frac{t}{N}$ ....

عدد الاهتزازات

r (m)	N	t (s)	T (s)	T^2 (s^2)	r^2 (m^2) $\times 10^3$
5cm 0.05		زمن 5 اهتزازات	$\frac{t}{N} = \frac{t}{5}$		
10cm 0.10		12	2.5	6.25	0.01
15 cm 0.15	5	14	2.8	7.84	0.0225
20cm 0.20		17	3.4	11.56	0.04
0.25					
0.30					

10
22.5
40

By plotting T^2 versus r^2 the slop =........ 186.7 s^2/m^2 ....

Calculating the restoring torque τ:

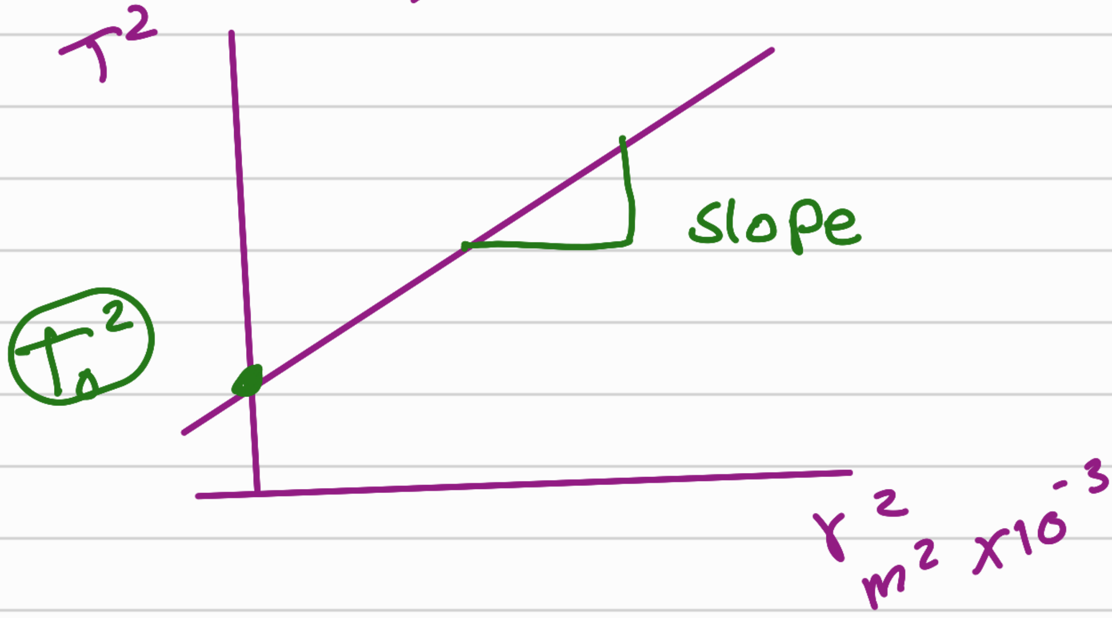
Equation used:

.... $\tau = \frac{8\pi^2 m}{slope}$ ....

The value of the restoring torque τ:

.... $\tau = \frac{8\pi^2 (0.236)}{186.7} = 0.099$ $kg\,m^2/s^2$

⑤ نرسم رسم بياني بين r^2 و T^2



⑥

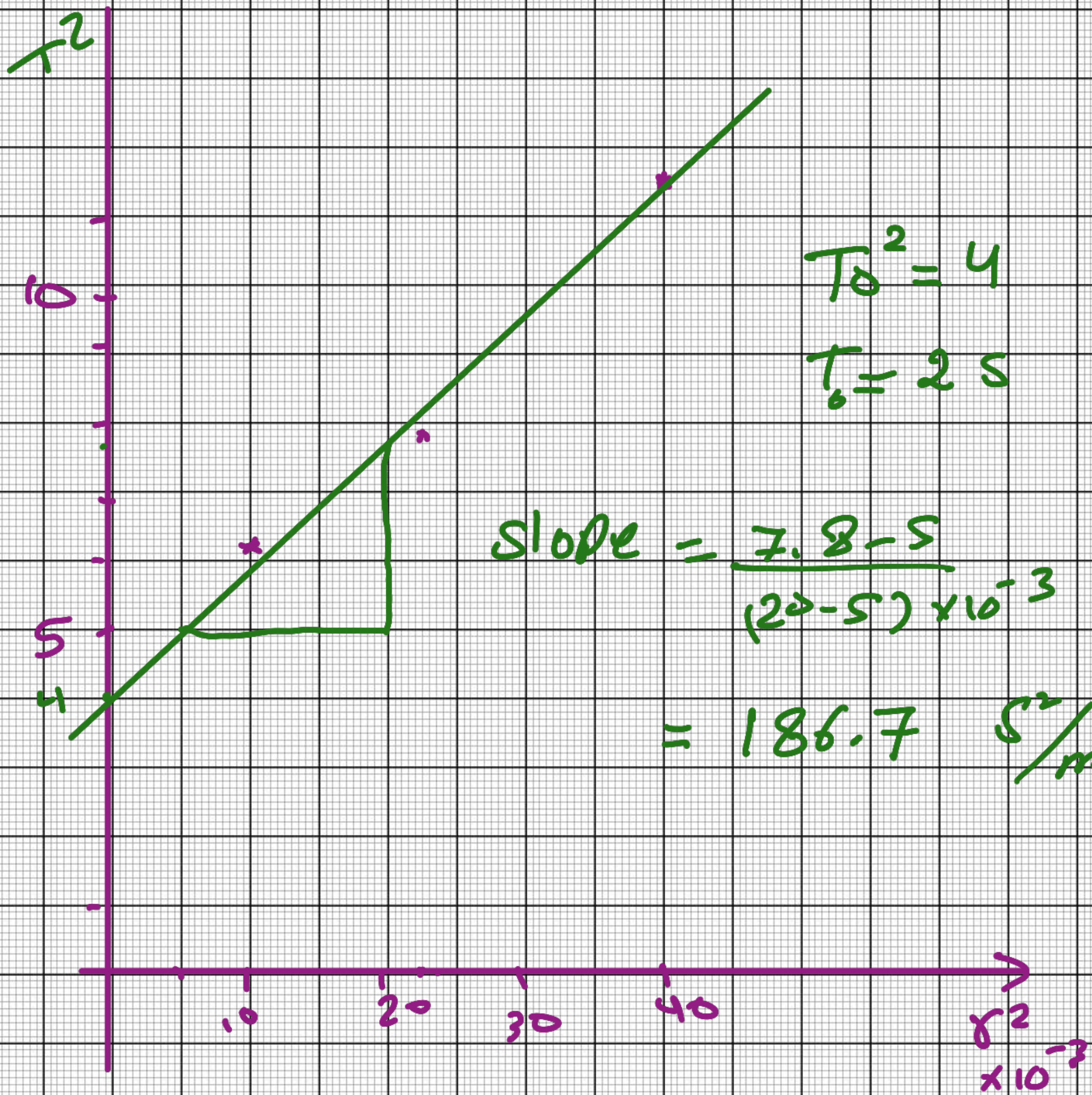
$$k = \frac{8\pi^2 m}{slope}$$

Part 2

$$I = k\left(\frac{T}{2\pi}\right)^2$$

نستخدم بيانات T وفيه k المحسوبة

لحساب I لكل حالة r



$T_0^2 = 4$

$T_0 = 2\ s$

$$\text{slope} = \frac{7.8 - 5}{(20 - 5) \times 10^{-3}}$$

$$= 186.7\ s^2/m^2$$

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Part 2: – Calculating the Moment of Inertia of the System I:

From part 1 the restoring torque τ =....0.099.....

Equation used for calculating the moment of inertia of the system (I):

$I = \tau \left(\frac{T}{2\pi}\right)^2$

r (m)	T (s)	I $(kg.m^2)$
0.05	من الجدول السابق	$I = 0.099\left(\frac{T}{2\pi}\right)^2$
0.10	2.5	$= 0.99\left(\frac{2.5}{2\pi}\right)^2 = 0.015$
0.15	2.8	0.019
0.20	3.4	0.028
0.25		
0.30		

kg m²

Observations:

Describe the relation between the distance r and the moment of inertia I of the system.

as radius increase

Inertia is increase

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For Engineering

Experiment 6

Maxwell's Wheel (1) – Moment of Inertia

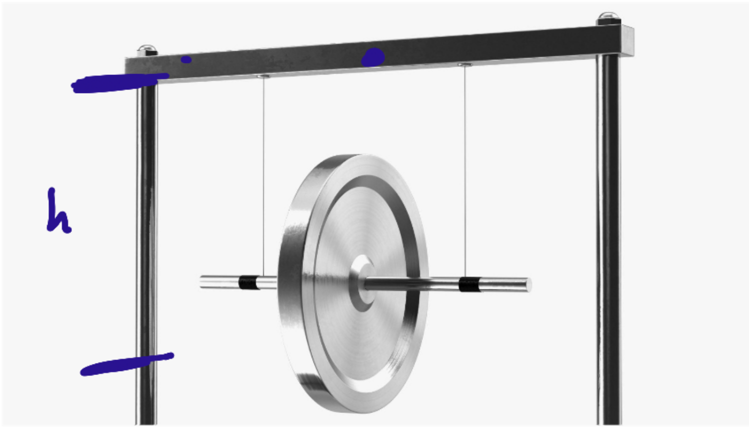
University ID Number: …………………..…………………………

Group Number: ………………………………………………………

- **Objectives**:

الهدف : حساب I لعجلة ماكويل

- **Apparatus**:



- **Theory**:

$$E = E_{pot} + E_{tran} + E_{rot}$$

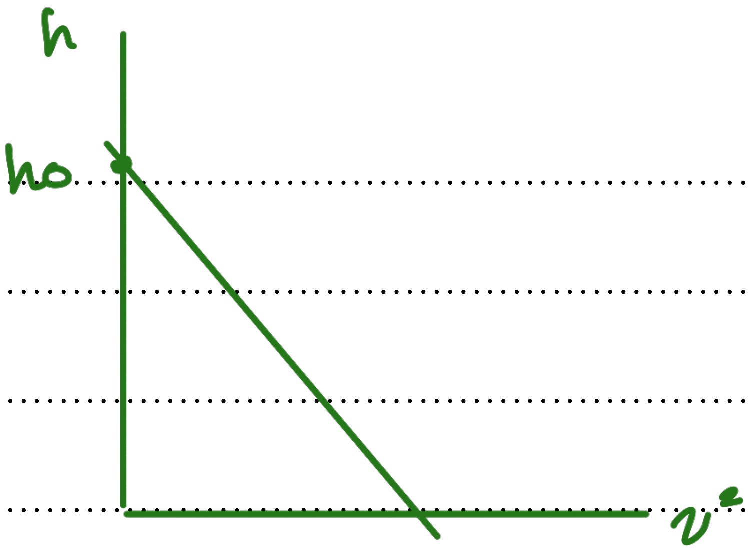
$$E = mgh + \frac{1}{2}mv^2 + \frac{1}{2}I\frac{v^2}{r^2}$$

$$mgh_0 = E_0$$ في أعلى نقطة

$$mgh_0 = mgh + \frac{1}{2}mv^2 + \frac{1}{2}I\frac{v^2}{r^2}$$

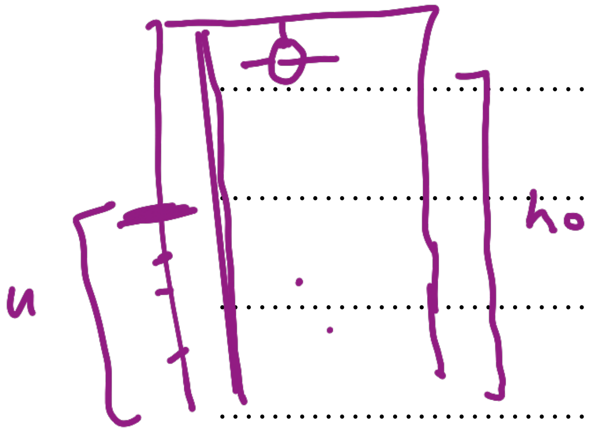
$$h = \left(-\frac{1}{2g} - \frac{I}{mgr^2}\right)v^2 + h_0$$

slope



فقط

$$I = -mr^2(1 + 2g \, slope)$$

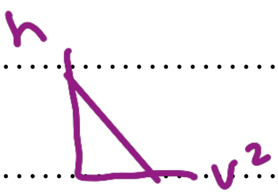


① نلف العجلة الى اقصى ارتفاع ونطلقها

② نغير قيمة h بمقدار 5cm ونحسب قيمة (t)

③ نحسب V كل مرة

$$V = \frac{d}{t} = \frac{\text{قطر العجلة}}{\text{الزمن}}$$



④ نرسم الرسم البياني

$h_0 \approx 0.5$ slope

- **procedures**:

The mass of the wheel m =450 g= 0.450 kg

The diameter of the spindle d =6 mm= 0.006 m

The radius of the spindle r =3 mm= 0.003 m

$V = \frac{d}{t}$

$V = \frac{0.006}{30 \times 10^{-3}}$

h_o (m)	h (m)	t (ms)	t (s) $\times 10^{-3}$	v (m/s)	v^2 $(m/s)^2$
	0.05	30	30	0.2 m/s	0.04 m/s²
	0.10			0.161	0.026
	0.15			0.131	0.017
	0.20			0.123	0.015
0.5	0.25			0.11	0.012
	0.30			0.105	0.011
	0.35				
	0.40				
	0.45				

By plotting h versus v^2 the slop (m) =…… −13.3 S²/m ……

Calculating the moment of inertia of the wheel I_{exp}:

Used equation:

…… $I = -mr^2(1 + 2g\,\text{slope})$ ……

The experimental value of moment of inertia of the wheel I_{exp}:

…… $I = -0.45(3\times10^{-3})^2(1+2(9.8)(-13.3))$

$= 0.00105 = 1.05\times10^{-3}\ kg\,m^2$

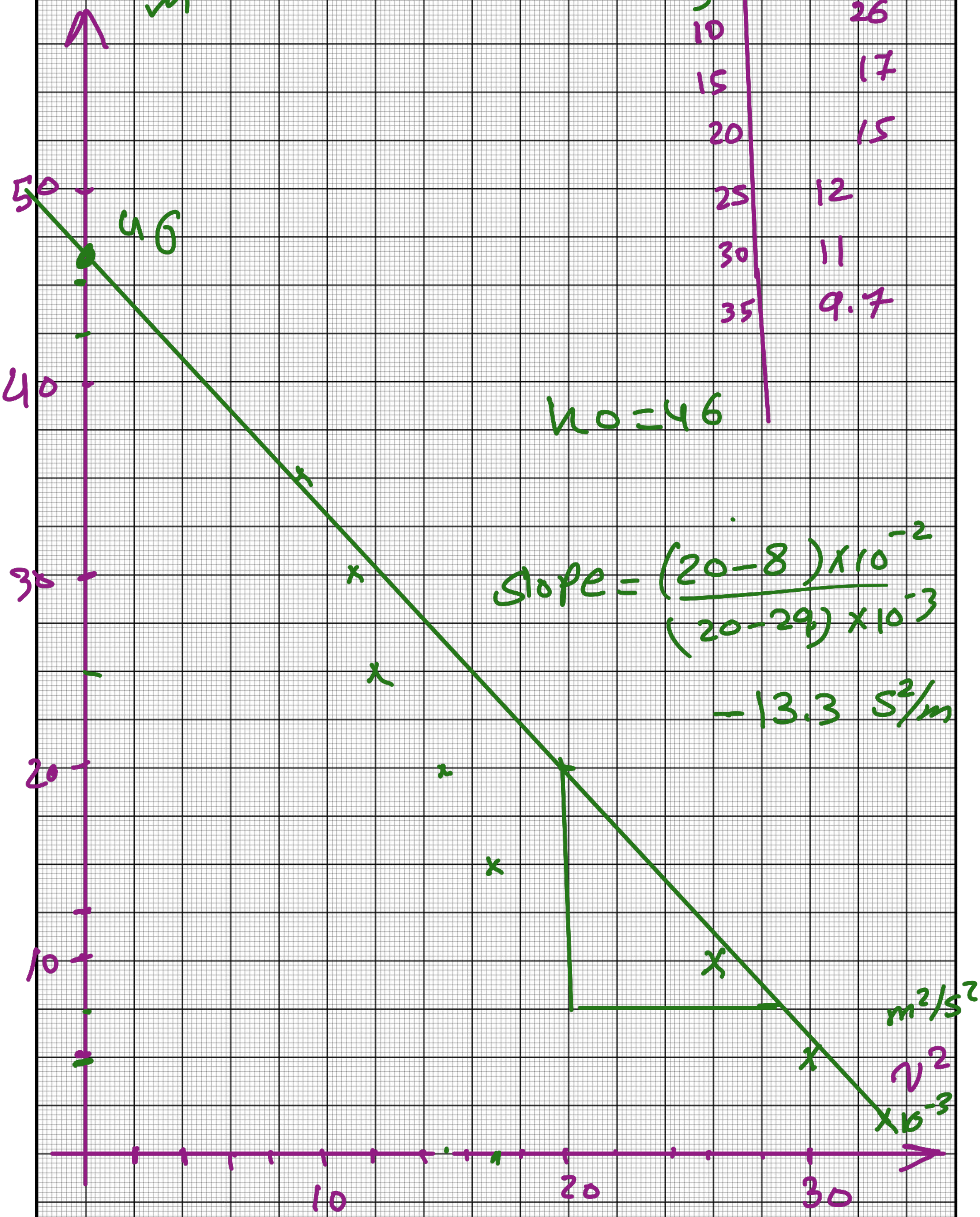
Calculating the percentage error:

Equation used:

…… $\left|\frac{I_{th} - I_{exp}}{I_{th}}\right| \times 100\%$ ……

If $I_{th} = 0.001\ kg.m^2$, the percentage error value in I_{exp}:

…… $\left|\frac{0.001 - 0.00105}{0.001}\right| \times 100\%$ ……



$h \times 10^{-2}$	$v^2 \times 10^{-3}$
5	30
10	26
15	17
20	15
25	12
30	11
35	9.7

$h_0 = 46$

$$\text{slope} = \frac{(20-8)\times 10^{-2}}{(20-29)\times 10^{-3}}$$

$-13.3\ s^2/m$

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Experiment 7

Maxwell's Wheel (2) – Conservation of Mechanical Energy

حفظ الطاقة الميكانيكية.

University ID Number: ……………….…………………………

Group Number: ………………………………………………….

- **Objectives**:

- **Apparatus**:

$$E = E_{pot} + \underbrace{E_{tran} + E_{rot}}_{E_{kin}}$$

$$E = E_{pot} + E_{kin}$$

- **Theory**:

$$E_{pot} = mgh$$

$$E_{tran} = \frac{1}{2} m v^2$$

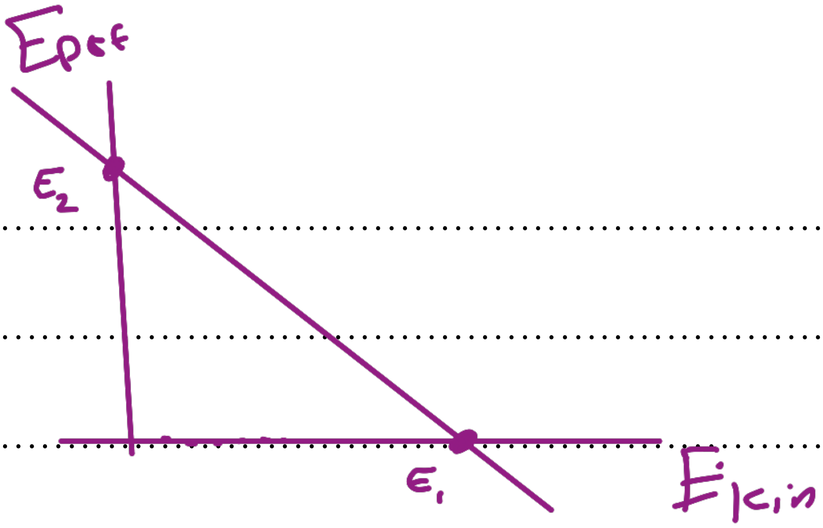
$$E_{rot} = \frac{1}{2} I \omega^2$$

اذا كان النظام محافظ تكون الطاقة

محفوظة و E مقدارها ثابت

اي ان النقصان في E_{pot} يقابله

زيادة في E_k



$E = \frac{E_1 + E_2}{2}$ = الطاقة الكلية

① نملأ الجدول بقيم h و v

من التجربة (6)

② نحسب قيم الطاقة باستخدام العلاقات

$E_{pot} = mgh$ ✓

$E_{tran} = \frac{1}{2} m v^2$

$E_{rot} = \frac{1}{2} I \omega^2$

I من نتيجة تجربة $6 = 1.05 \times 10^{-3}$

$\omega = \frac{v}{r} = \frac{\text{السرعة}}{\text{نصف القطر}}$

$E_{pot} = mgh = 0.45 \times 9.8 \times 0.05 = 0.2205\ J$

$E_{tran} = \frac{1}{2} m v^2 = \frac{1}{2} \times 0.45 \times (0.17)^2 = 0.0065\ J$

$E_{rot} = \frac{1}{2} I \frac{v^2}{r^2} = \frac{1}{2} \times 1.05 \times 10^{-3} \times \frac{(0.17)^2}{0.003^2} = 1.685$

$E_k = 0.0065 + 1.685 = 1.6915$

- **procedures**:

From part experiment 6 the moment of inertia I_{exp} = 1.05x10^{-3}

The mass of the wheel m =450 g= 0.450 kg

The radius of the spindle r =3 mm= 0.003 m

h (m)	v (m/s)	E_{pot} (J)	E_{tran} (J)	E_{rot} (J)	E_{kin} (J)
0.05	0.17m/s	0.2265	0.0065	1.685	1.6915
0.10	0.161	0.441	0.005	1.512	1.517
0.15	0.131	0.661	0.004	1.061	1.065
0.20	0.123	0.822	0.0034	0.882	0.885
0.25	0.11	1.025	0.0027	0.706	0.7087
0.30	0.105	1.323	0.0025	0.643	0.6455
0.35					
0.40					
0.45					

Observations:

By analysing data in table above, describe the transformation of the potential energy into the translational and rotational energy.

As the hight is decrease the Potential energy transform to K_{trans} or K_{rot}

By analysing the graph E_{pot}, E_{kin} versus the hight h, describe the transformation of the potential energy into kinetic energy.

when potential energy decrease E_{kin} increase and thier total around 1.8 J

Epot

Epot	Ekin
0.2205	1.6915
0.441	1.517
0.661	1.065
0.822	0.885
1.025	0.7087
1.323	0.6455