Graph of .... Scale x axis ....

Reg NO:- ENG/19/MEC/00289

Date:- Y axis ....

Experiment 1

Tittle:- Sliding Friction

Aim:- i. To find the coeffient of friction for steel and aluminium surfaces sliding on a steel inclined plane.

ii. To show that forces (applied parrallel to the plane) required to slide a block up the plane is equal to: $mg(\sin\alpha + \mu\cos\alpha)$

where α = angle of inclination of the plane, μ = coeffient of friction between the surfaces involved, m = mass of the block, and g is the acceleration due to gravity.

Theory:- A block placed on an inclined surface has the tendency of sliding down the plane. For small angle of inclination the block is prevented from sliding by the frictional force (F) between the surfaces. A sufficient increase in the angle of inclination causes the block to slide down the plane. Under this condition, the force exerted down the plane due to the weight of the block has overcome the friction force between the surfaces. The angle at which sliding first occurs is called the angle of friction, θ.

From Fig. 1.1a it is easily shown that:

$$F = mg\sin\theta \text{ and } N = mg\cos\theta$$

The coefficient of friction (μ) between the two surfaces is defined as:

$$\mu = F/N = \tan\theta$$

If a force p is applied to the block parallel to the plane inclined at an angle α to pull the block up the plane then consider when the force p is just sufficient to slide the block up the plane.

Scale x axis ....

Y axis ....

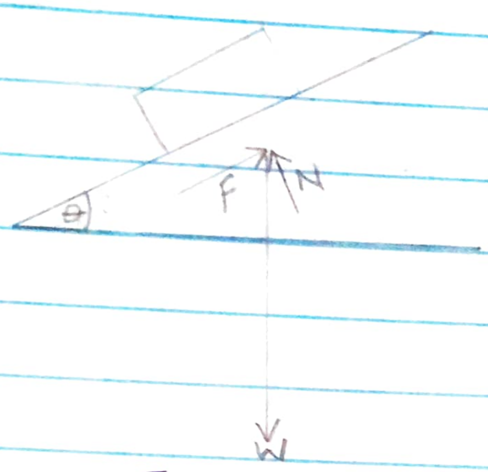

Fig. 1.1a

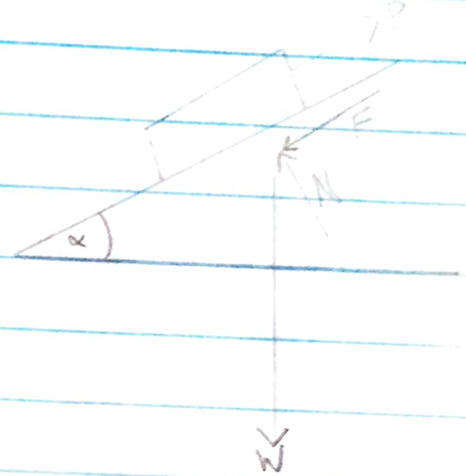

Fig. 1.1b

$$P = mg\sin\alpha + F \text{ and } N = mg\cos\alpha$$

But $F = \mu N$, so $P = mg(\sin\alpha + \mu\cos\alpha)$

For a special case where α equal to the angle of friction θ between the corresponding surfaces, $\mu = \tan\theta$ and P becomes

$$P = mg(\sin\alpha + \tan\theta\cos\theta) = 2mg\sin\theta$$

Apparatus:- Steel inclined plane with plumb bob; Friction blocks (double sided) of mass 0.74 Kg; weight hooks; Sets of weight; Spring balance and pulley.

Procedures:-

1. We Measured and recorded the masses of friction blocks with the spring balance. Place the steel side of the friction block on the inclined steel plane and carefully increase the angle of the plane until the block just slips (moves with uniform speed down the slope). Measured the

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Graph of .... Scale x axis ....

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angle of the plane using the plumb bob. Which was gotten to be the angle of friction θ. We repeated the exercise as a check. We repeated the test with 1kg and 2kg to the block, each time measuring the angle of friction θ. We repeated the test with aluminum side of the inclined plane.

2. We attached the block to the weight hook by a string passing over a pulley. We set the angle of incline of the plane to an angle α different from angle θ obtained in (1). Which the steel side of the block on the inclined plane carefully we added masses to the weight hook untill the block moves with a slow uniform speed up the plane. We recorded the weight P (including the weight of the hook) required to move the block up the inclined plane. Repeat the exercise as a check which we did. We repeted the test with 1kg, 2kg added to the block in turn. We Respeated the whole test with aluminum side of the block on the inclined plane.

3. We adjusted the angle of incline of the plane to the angle of friction θ for the surface we obtained in 1. We now reapeted the test 2.

Results:- Table 1: Steel to steel surface

Weight (N)	θ(°)	μ = tan θ	α(°)	P (by Calculation) (N)	P (by experiment) (N)
7.26	21	0.5543	30	5.93	6.84
17.17	27	0.5095	30	16.49	16.65
22.07	27	0.5095	30	20.77	21.73
31.88	28	0.5317	30	30.62	31.37

Graph of .... Scale x axis ....

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.... Y axis ....

Table 2: Aluminum to Steel Surface.

Weight(N)	θ°	$H = \tan\theta$	α°	P (by calculation) (N)	P (by experiment) (N)
7.26	19	0.3443	25	5.33	5.87
17.17	20	0.3640	25	13.23	13.71
22.07	21	0.3839	25	17.01	17.64
31.88	23	0.4245	25	25.74	26.47

~~Me~~ Steel to Steel Calculations of P values

Calculations of P values. Using $P = mg(\sin\alpha + H\cos\alpha)$ where $H = \tan\theta$ and $\alpha = 30^\circ$ for steel to steel and $\alpha = 25^\circ$ for aluminum to steel, mg= ~~varies~~ mass x $9.81 m/s^2$ = (N)

When mg = 7.26 N

$\therefore P = 7.26(\sin(30) + (0.5543 \times \cos(30))$

$P = \cancel{5.33N}$ 5.93 N

When mg = 17.17N

$\therefore P = 17.17(\sin(30) + (0.5095 \times \cos(30))$

$P = 16.49N$

When mg = 22.07N

$\therefore P = 22.07(\sin(30) + (0.5095 \times \cos(30))$

$P = 17.01N$

When mg = 31.88N

$\therefore P = 31.88(\sin(30) + (0.5317 \times \cos(30))$

$\therefore P = 30.62N$

Graph of ....   Scale x axis ....

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Calculations of Aluminum to Steel Surfaces to get P values

When $Mg = 7.26N$

$\therefore P = 7.26(\sin(25) + (0.3443 \times \cos(25)))$

$P = 5.33N$

When $mg = 17.17N$

$\therefore P = 17.17(\sin(25) + (0.3640 \times \cos(25)))$

$P = 13.23N$

When $mg = 22.07N$

$\therefore P = 22.07(\sin(25) + (0.3839 \times \cos(25)))$

$P = 17.01N$

When $mg = 31.88N$

$\therefore P = 31.88(\sin(25) + (0.4245 \times \cos(25)))$

$P = 25.74N$

Discussion Of Results

From the results above, it can be clearly seen that the angle of friction I obtained are reasonable due to the values of the pull force (P) obtained by calculations and those obtained by experiments are approximately close and equal. This shows that the formular for calculating the pull up force $(P) = mg(\sin\alpha + \mu\cos\alpha)$ is correct and confirmed.

The relative values of angles of friction were affected as the weight of the block was increased.

The relative values of friction were also affected as the surface of the block was changed from steel to aluminum surface. For steel

Graph of .... Scale x axis ....

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Surface it needed a higher inclination of the plane to slide down but for aluminum surface it needed lesser inclination to slide down the plane.

The slight differences observed in the values of P obtained by calculations and by experiments is as a result of the experimental errors encountered during the experiment.

Also it is observed that longer pull force (P) is required to over come friction when the angle of inclination increases.

If α is small the block is prevented from sliding by the frictional force which clearly shows that the pull force (P) is not large enough to cause sliding or to over come friction

Precautions:-

- The assembly was moved up slowly in order to obtain the correct angle of friction.
- It was ensured that the weights were added gently to the weighing hook when the pull force (P) was placed.
- The plane was cleaned to remove any particle which will prevent the friction block from moving uniformely.

Sources of error:-

- When trying to obtain the angle of friction, the effect of air resistance on the friction block caused some variation in the readings obtained
- Error due to parallax when taking reading from the protractor.

Graph of .... Scale x axis ....

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~~Concult~~

Conclusion

The formula $P = mg(\sin\alpha + \mu\cos\alpha)$ for the pull up force (P) of the sliding friction experiment was found to be correct. This is because the values of P obtained by calculations were very close to the values of P by experiment. Hence the formular was verified.

Also the slight differences between the values of P by experiments and P by calculation was due to experimental errors.

END OF EXPERIMENT 1.

Graph of .... Scale x axis ....

Reg NO:- ENG/119/MEC/00289

Date:- Y axis ....

Experiment 2:

Tittle: Coeffient of Friction of Belt drive.

Aim:-(1) To examine the frictional behaviour of a loaded belt in contact with a moving pulley.

(2) To verify the theory of belt friction.

Introduction/Theory:-

One of the most common ways of transmitting power between two shafts centres is to use a belt, this particularly so if the distance between the shafts centres is long. There are esentially two types of belt which use friction drive. These are flat belts and v belts.

The power transmitted by a belt depends on the net friction transmitted from one pully to the other and on the belt speed. The force transmitted depends on the frictional grip of the pulley on the belt which is affected by:-

a) The ratio of tensions on the tight and slack sides,

b) The angle of lap where the belt is in contact with the pulley, and

c) The inertia effort, where the centrifugal force tends to lift the belt of the pulley at high speeds.

Flat Belt Theory

let T1 = tension on the tight sides

T2 = tension on slack side.

Graph of .... Scale x axis ....

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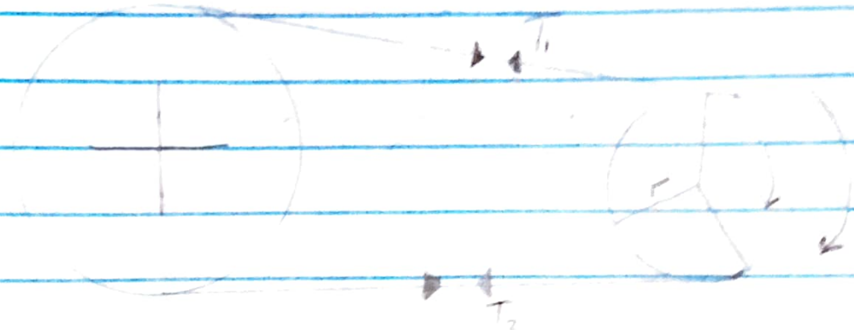

Fig. 2.1a

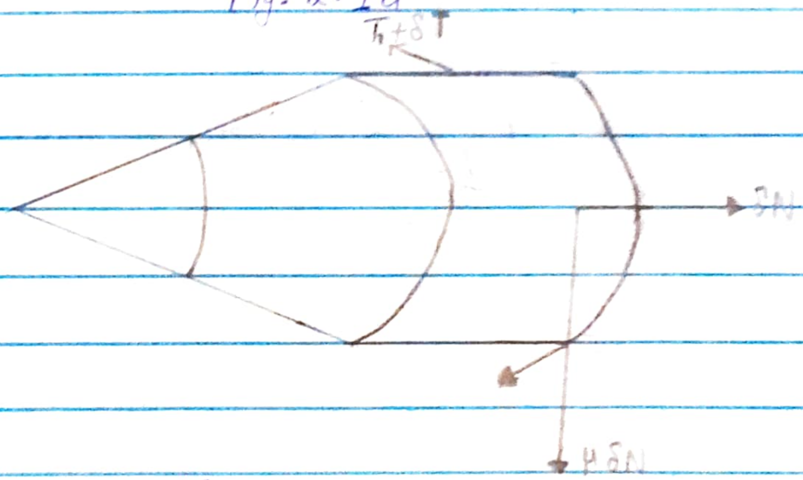

Fig. 2.1b

Consider the forces action on a small element of the belt, subtending an angle $\delta\theta$ at the centre of the smaller pulley (where the conditions are most critical) Assuming limiting friction conditions exist at all points of contact.

Resolving Radially

$$(T+\delta\theta)\sin\frac{\delta\theta}{2} + T\sin\frac{\delta\theta}{2} = \delta N + (mr\,\delta\theta)\frac{V^2}{r}$$

where: T = tension in direction of rotation; $\delta\theta$ = increase in tension across element; N = radial reaction between pulley and belt; V = linear belt speed a pheripheral speed of pulley; m = mass of belt per unit length.

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Now if $\delta\theta$ is very small $\sin(\delta\theta/2) \simeq \delta\theta/2$ and neglecting multiples of too small values, the equation becomes:

$$\Delta T - mvr\delta\theta = \delta N \text{ ——— (1)}$$

Resolving Tangentially

$$(T+\delta T)\cos\frac{\delta\theta}{2} - T\cos\frac{\delta\theta}{2} = \mu\delta N$$

For small $\delta\theta$, $\cos(\delta\theta/2) \simeq 1$, hence the equation becomes:

$$\delta T = \mu\delta N \text{ ——— (2)}$$

Combining equations (1) and (2) we get:

$$\delta T = \mu\delta\theta(T - mv^2) \text{ ——— (3)}$$

From which,

$$\int\frac{\delta T}{(T-mv^2)} = \int\mu\delta\theta$$

Integrating between T1 and T2, 0 and θ, gives

$$\log_e\frac{T1 - mv^2}{T2 - mv^2} = \mu\theta,$$

Or

$$\frac{T1 - mv^2}{T2 - mv^2} = e^{\mu\theta} \text{ ——— (4)}$$

Under static or low speed conditions mv^2 (the centrifugal tension) can be ignored and hence

$$\frac{T1}{T2} = e^{\mu\theta}$$

Note θ is in radians

Vee-Belt Theory

Let the total angle of the pulley flanges be $2B$ and the normal reaction at the pulley face be N, the radial component of $N = N\sin(90-\beta)$

Hence the total radial force is $N = 2N\sin(B)$ ——— (5)

Also total friction is $= 2\mu N$ ——— (6)

If these values from (5) and (6) are substituted in the derivation of the equation for flat belt above, we have:

Graph of .... Scale x axis ....

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.... Y axis ....

$$\frac{T_1}{T_2} = e^{\mu\beta \operatorname{Cosec} \beta}$$

The value $\mu \operatorname{Cosec} \beta$ is termed the effective coefficient of friction.

Fig. 2.2a

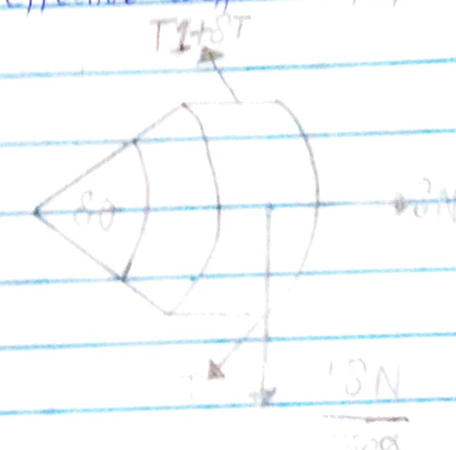

Fig. 2.2b

Apparatus: The cusson Rope, belt and coil friction apparatus P6147 mounted on the wall and ~~two~~ weight hooks.

Method:

1 Flat Belt:

The flat belt was placed across the flat surface of the main pulley and jockey pulley. The board was rotated untill the required angle of lap was 90° and the position was locked in by tightening the dished hand wheel in the centre. A load of 1 kg was applied to the tight side (the side hanging vertically from the main pulley and masses where added to the hanger on the slack side untill the tendency of slip just ceases (limiting friction). Then T1, T2, LnT1 and lnT2 was recorded. The ~~step~~ was reapeated for increasing load

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On the tight side in steps of 1Kg, taking care not to over load the belt.

2. Vee-Belt

The vee belt provided ~~was~~ used in this experiment sat on the Vee-grove of the pulley's set up as for the flat belt experiment, but in addition the angle 2β was measured of the pulley flanges and hence β was found.

Table Of Results

Graph of .... Scale x axis ....

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.... Y axis ....

Table Of Results

Flat Belt : Table of values for a flat belt drive

S/N	T1 (kg)	T2 (kg)	$\ln T1$	$\ln T2$
1	1.00	0.50	0.00	-0.69
2	2.00	1.20	0.6931	0.18
3	3.00	1.90	1.0986	0.64
4	4.00	2.40	1.3863	0.88
5	5.00	3.20	1.6094	1.16

Vee Belt : Table of values for a vee belt drive

S/N	T1 (kg)	T2 (kg)	$\ln T1$	~~$\ln T2$~~	$\ln T2$
1	1.00	0.50	0.00	~~-1.61~~	-0.69
2	2.00	1.00	0.69	~~-0.30~~	0.00
3	3.00	1.50	1.10	~~0.40~~	0.41
4	4.00	2.00	1.39	~~0.69~~	0.69
5	5.00	2.50	1.61	~~0.92~~	0.92

Calculations:-

Given Depth $= h = 13.20$mm, thickness $= a = 4.90$mm and $b = 12.00$mm. Using the formular: $h = \frac{b-a}{2\beta}$

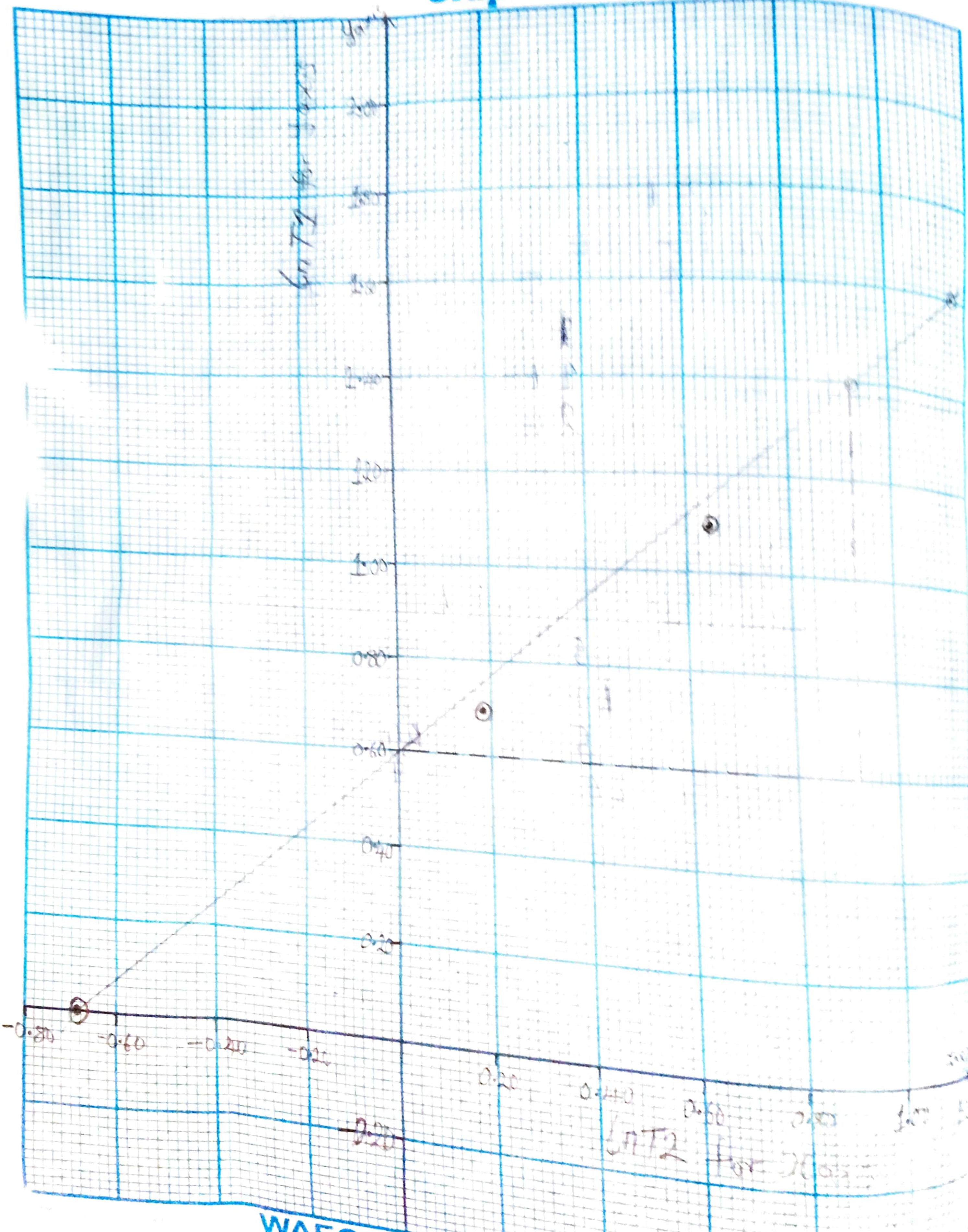
making 2β subject of the formular $\therefore 2\beta = \frac{b-a}{h}$

$\therefore 2\beta = \frac{12 - 4.90}{13.20} = 0.54$mm

$\therefore 2\beta = 0.54^\circ$ $\beta = \frac{0.54}{2} = 0.27^\circ$

graph of lnT1 against lnT2 in Flat Belt Drive

Graph



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Graph of .... Scale x axis ....

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.... Y axis ....

Slope of the graph of a flat belt drive:-

$$\text{Slope} = \frac{y_2 - y_1}{x_2 - x_1} = \frac{\ln T1_2 - \ln T1_1}{\ln T2_2 - \ln T2_1}$$

$$= \frac{1.40 - 0.60}{0.90 - 0.00} = \frac{0.8}{0.9} = \underline{\underline{0.89}}$$

Intercept:- The graph intercept cuts the lnT1 axis at 0.60 while at lnT2 it cuts at −0.69

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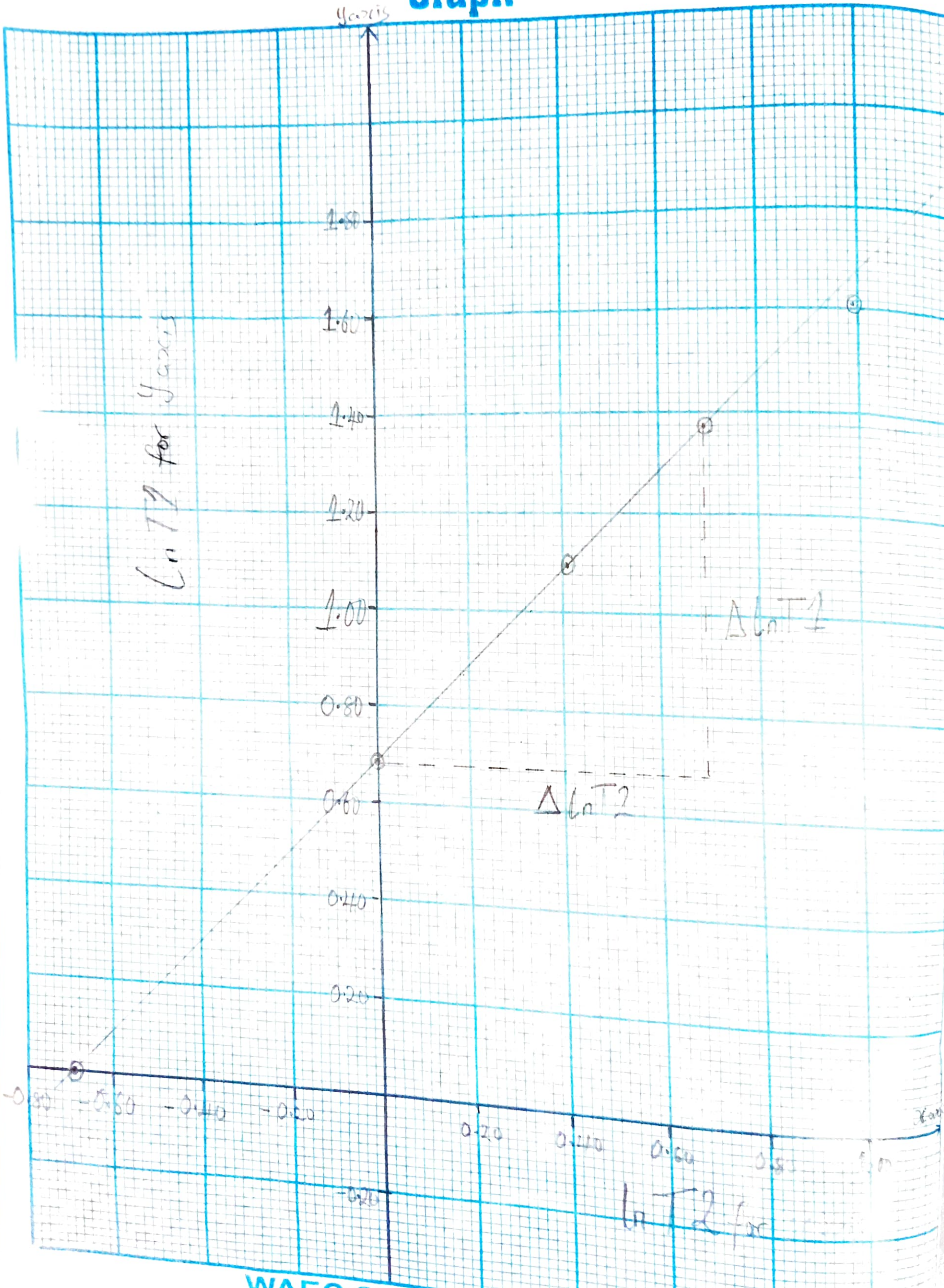
Tittle: Graph of lnT1 against lnT2 for Vee-belt drive

Slope :- X axis :- let 2cm represent 0.2un

Y axis :- let 2cm represent 0.2uni

Graph



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Graph of .... Scale x axis ....

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Slope of the graph for Vee belt drive:

$$\text{Slope} = \frac{\Delta \ln T1}{\Delta \ln T2} = \frac{\ln T1_2 - \ln T1_1}{\ln T2_2 - \ln T2_1}$$

$$= \cancel{0.69} = \frac{1.39 - 0.69}{0.69 - 0.00} = \underline{\underline{1.01}}$$

Intercept:- The graph intercept cuts the $\ln T1$ axis at 0.69 and the $\ln T2$ axis at −0.69

Discussion/Interpretation Of Results:-

1) The two graphs are straight line graph of flat belt drive and vee belt drive are on the straight line. That is they are linear.
It can also be seen from the graphs that the flat belt drive graph intercept cut the $\ln T1$ at 0.60 and the $\ln T2$ at the −0.69 point.
For the vee-belt drive Graph the intercept cut the $\ln T1$ at 0.69 and the $\ln T2$ at −0.69.

2) The intercept of the graph represents the product of the coefficient of friction and the angle of lap.

Conclusion:-

We observed that from the table of values of flat belt drive and vee-belt drive, the values of both $\ln T1$ and $\ln T2$ increase respectively.