AMIRAJ
COLLEGE OF ENGINEERING & TECHNOLOGY

LABORATORY MANUAL

DYNAMICS OF MACHINERY

SUBJECT CODE: 3151911

MECHANICAL ENGINEERING DEPARTMENT

B.E. 5th SEMESTER

NAME:______________________________

ENROLLMENT NO: ______________________________

BATCH NO: ______________________________

YEAR: ______________________________

Amiraj College of Engineering and Technology,
Nr.Tata Nano Plant, Khoraj, Sanand, Ahmedabad.

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COLLEGE OF ENGINEERING & TECHNOLOGY

Amiraj College of Engineering and Technology,

Nr.Tata Nano Plant, Khoraj, Sanand, Ahmedabad.

CERTIFICATE

This is to certify that Mr. / Ms. ____ Of class____________________ Enrolment No ___________________________has Satisfactorily completed the course in ____________________________________as by the Gujarat Technological University for ____ Year (B.E.) semester___ of Mechanical Engineering in the Academic year_______.

Date of Submission:-

Faculty Name and Signature

(Subject Teacher)

Head of Department

(Mechanical)

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List Of Experiments

Sr. No.	Title	Date of Performance	Date of submission	Sign	Remark
1	To study the oscillation of simple pendulum				
2	To determine the radius of gyration of a compound pendulum				
3	To determine the radius of gyration of a body using bifilar suspension				
4	To determine radius of gyration of disc using Trifilar suspension				
5	To study the torsional vibrations of single rotor system				
6	To study the torsional vibrations of two rotor system				
7	To study damped torsional vibrations of single rotor system				
8	To study undamped free vibrations of a spring				
9	To calculate equivalent spring stiffness for spings in series.				
10	To study the natural vibrations of a spring mass system				
11	To study forced damped vibration of a spring mass system				
12	To verify Dunkerely’s rule for transverse vibrations				
13	To study the forced damped vibrations of Simply supported beam				

INTRODUCTION

In simplest terms, vibration in motorized equipment is merely the back and forth movement or oscillation of machines and components, such as drive motors, driven devices (pumps, compressors and so on) and the bearings, shafts, gears, belts and other elements that make up mechanical systems.

Vibration in industrial equipment can be both a sign and a source of trouble. Other times, vibration just “goes with the territory” as a normal part of machine operation, and should not cause undue concern.

Vibration is not always a problem. In some tasks, vibration is essential. Machines such as oscillating sanders and vibratory tumblers use vibration to remove materials and finish surfaces. Vibratory feeders use vibration to move materials. In construction, vibrators are used to help concrete settle into forms and compact fill materials. Vibratory rollers help compress asphalt used in highway paving.

In other cases, vibration is inherent in machine design. For instance, some vibration is almost unavoidable in the operation of reciprocating pumps and compressors, internal combustion engines, and gear drives. In a well-engineered, well-maintained machine, such vibration should be no cause for concern.

When vibration is a problem

Most industrial devices are engineered to operate smoothly and avoid vibration, not produce it. In these machines, vibration can indicate problems or deterioration in the equipment. If the underlying causes are not corrected, the unwanted vibration itself can cause additional damage.

Most common causes of machine vibration

Vibration can result from a number of conditions, acting alone or in combination. Keep in mind that vibration problems may be caused by auxiliary equipment, not just the primary equipment. These are some of the major causes of vibration.

Imbalance – A “heavy spot” in a rotating component will cause vibration when the unbalanced weight rotates around the machine’s axis, creating a centrifugal force. Imbalance could be caused by manufacturing defects (machining errors, casting flaws) or maintenance issues (deformed or dirty fan blades, missing balance weights). As machine speed increases, the effects of imbalance become greater. Imbalance can severely reduce bearing life as well as cause undue machine vibration.

Misalignment/shaft runout – Vibration can result when machine shafts are out of line. Angular misalignment occurs when the axes of (for example) a motor and pump are not parallel. When the axes are parallel but not exactly aligned, the condition is known as parallel misalignment. Misalignment may be caused during assembly or develop over time, due to thermal expansion, components shifting or improper reassembly after maintenance. The resulting vibration may be radial or axial (in line with the axis of the machine) or both.

Wear – As components such as ball or roller bearings, drive belts or gears become worn, they may cause vibration. When a roller bearing race becomes pitted, for instance, the bearing rollers will cause a vibration each time they travel over the damaged area. A gear tooth that is heavily chipped or worn, or a drive belt that is breaking down, can also produce vibration.

Looseness – Vibration that might otherwise go unnoticed may become obvious and destructive if the component that is vibrating has loose bearings or is loosely attached to its mounts. Such looseness may or may not be caused by the underlying vibration. Whatever its cause, looseness can allow any vibration present to cause damage, such as further bearing wear, wear and fatigue in equipment mounts and other components.

Effects of vibration

The effects of vibration can be severe. Unchecked machine vibration can accelerate rates of wear (i.e. reduce bearing life) and damage equipment. Vibrating machinery can create noise, cause safety problems and lead to degradation in plant working conditions. Vibration can cause machinery to consume excessive power and may damage product quality. In the worst cases, vibration can damage equipment so severely as to knock it out of service and halt plant production.

Yet there is a positive aspect to machine vibration. Measured and analyzed correctly, vibration can be used in a preventive maintenance program as an indicator of machine condition, and help guide the plant maintenance professional to take remedial action before disaster strikes.

Characteristics of vibration

To understand how vibration manifests itself, consider a simple rotating machine like an electric motor. The motor and shaft rotate around the axis of the shaft, which is supported by a bearing at each end.

One key consideration in analyzing vibration is the direction of the vibrating force. In our electric motor, vibration can occur as a force applied in a radial direction (outward from the shaft) or in an axial direction (parallel to the shaft).

An imbalance in the motor, for instance, would most likely cause a radial vibration as the "heavy spot" in the motor rotates, creating a centrifugal force that tugs the motor outward as the shaft rotates through 360 degrees. A shaft misalignment could cause vibration in an axial direction (back and forth along the shaft axis), due to misalignment in a shaft coupling device.

Another key factor in vibration is amplitude, or how much force or severity the vibration has. The farther out of balance our motor is, the greater its amplitude of vibration. Other factors, such as speed of rotation, can also affect vibration amplitude. As rotation rate goes up, the imbalance force increases significantly.

Frequency refers to the oscillation rate of vibration, or how rapidly the machine tends to move back and forth under the force of the condition or conditions causing the vibration.

Frequency is commonly expressed in cycles per minute or hertz (CPM or Hz). One Hz equals one cycle per second or 60 cycles per minute. Though we called our example motor "simple", even this machine can exhibit a complex vibration signature. As it operates, it could be vibrating in multiple directions (radially and axially), with several rates of amplitude and frequency. Imbalance vibration, axial vibration, vibration from deteriorating roller bearings and more all could combine to create a complex vibration spectrum.

The various types of vibration are

1. Free Vibration: This is a type of vibration which can neither be induced nor stopped. They tend to vibrate forever. Some good known example known to me is the movement of electrons.

2. Forced Vibration: This is a type of vibration occurs due to forcing of a system to vibrate. The vibration of the leaves or the movements of the leaves in the trees or plants are good examples. But they tend to be damped or stopped due to the systems nature.

3. Damped Vibration: This is a type of vibration where a forced vibration or a self induced vibration is damped or stopped from causing further inconvenience. A good example of this would be dampening of vibrations in the automobile using shock absorbers.

4. Random Vibration: These occur very rarely and randomly in nature. A good example for this would be the earthquake, with nothing to tell us really about its magnitude and nature. These vibrations are hence very difficult for controlling

Conclusion

Vibration is a characteristic of virtually all industrial machines. When vibration increases beyond normal levels, it may indicate only normal wear – or it may signal the need for further assessment of the underlying causes, or for immediate maintenance action.

Understanding why vibration occurs and how it manifests itself is a key first step toward preventing vibration from causing trouble in the production environment.

DOM	UNIVERSAL VIBRATION APPARATUS **EXT-1 SIMPLE PENDULUM**

AIM:

To study the oscillation of simple pendulum

PROCEDURE:

Fix the balls with nylon ropes in to the hooks provided at the top of beam of the frame, and measure the length of pendulum as shown. Oscillate the pendulum and measure the time required for 30 oscillations. Repeat the procedure by changing the ball and changing the length

OBSERVATION:-

Sr. No.	Ball Size	Length L m	Time for 30 Oscillations

CALCULATIONS:

For Simple pendulum

Let,

t = time period sec/cycle

Therefore

$t = 2\pi (L/g)^{0.5}$ sec

Experimentally,

t_{exp}= (time for 30 oscillations) / 30

Compare the values obtained practically and theoretically. Also plot a graph of t^2 v/s L

CONCLUSION:-

Time period of the simple pendulum is proportional to the square root of the length L of simple pendulum.

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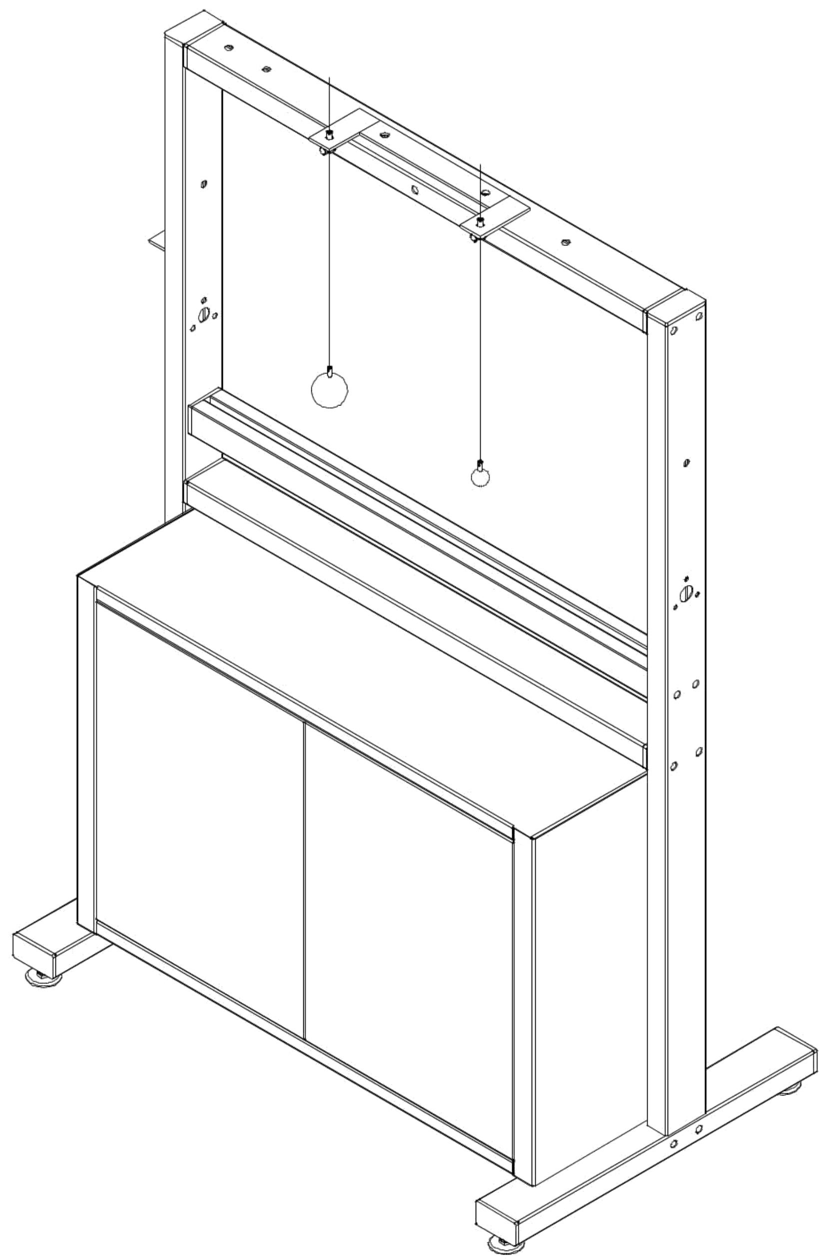

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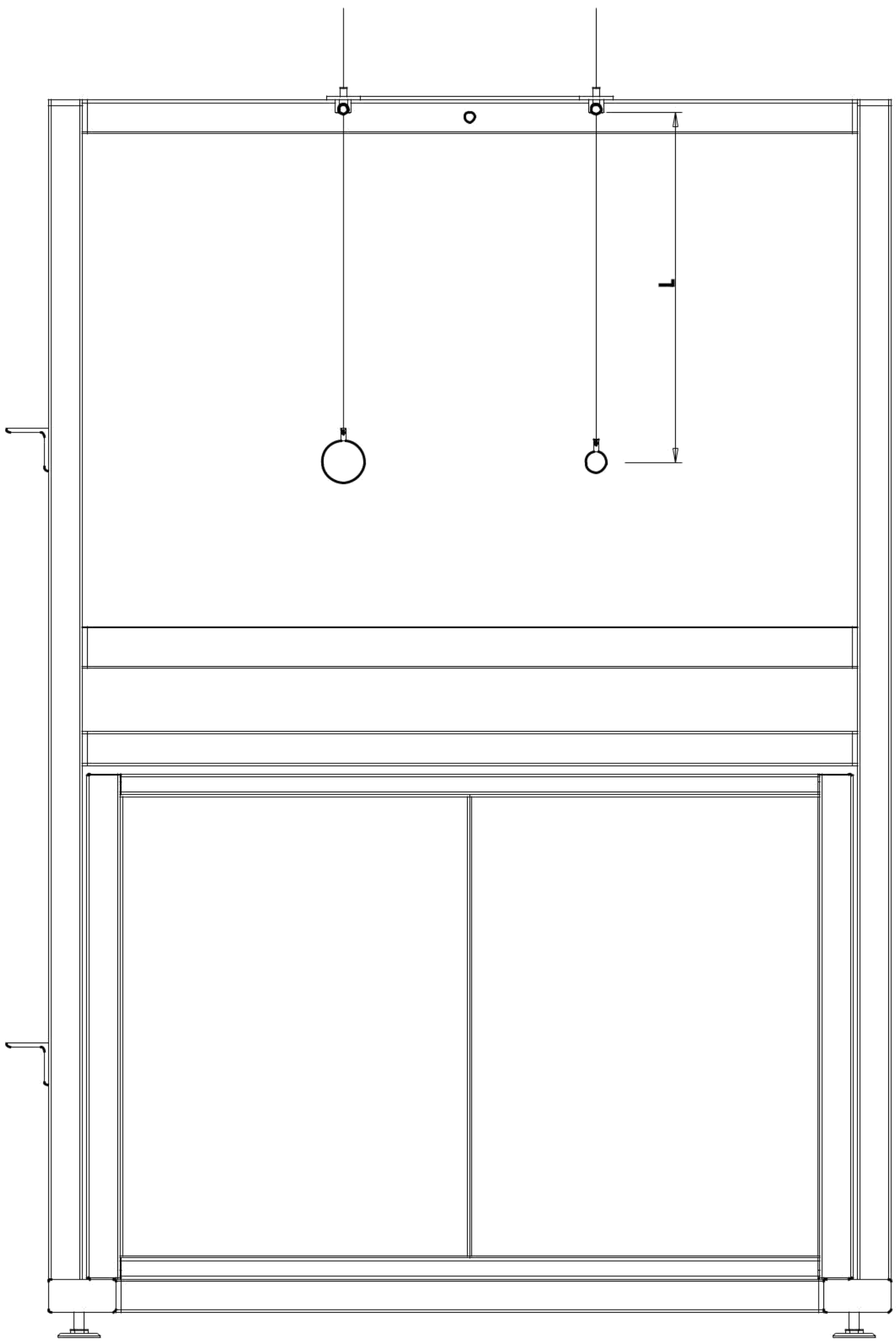

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AS PER ISO-2768 mk

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VB00-0000

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ALL DIMENSIONS ARE IN MM

Sample Calculations

Experiment – Simple Pendulum

Observation

Sr. No.	Ball Size	Length	Time for 30 oscillations
1	Big	359 mm	35 sec

Experimental Time Period: - 35/30 = 1.16

Theoretically t = 2 x 3.14 x $(0.359/9.81)^{0.5}$ = 1.201

Hence Verified

Reference video link:
https://www.youtube.com/watch?v=NrUuN4EK_kA
https://www.youtube.com/watch?vQOEEyuKPMY&list=PL7jfMV2bTYmpeem_8KY_xyfZg
VJiiInwf
https://www.youtube.com/watch?v=02w9lSii_Hs
https://www.youtube.com/watch?v=qmUayxi4izk

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UNIVERSAL VIBRATION APPARATUS

EXP-2 COMPOUND PENDULUM

AIM:

To determine the radius of gyration of a compound pendulum

INTRODUCTION:

A rigid body is allowed to oscillate in vertical plane about the axis of suspension under the action of gravitational force. This body is called a compound pendulum. The unit is provided with a compound pendulum with a simple design as shown in figure.

PROCEDURE:

Fix the brass bush in any of the holes of pendulum and mount the pendulum over the suspension shaft which is fitted at the top disc. Oscillate the pendulum and measure the time required for 5 oscillations. Repeat the procedure by putting the bush in different holes.

OBSERVATION:

h = distance of c.g. of axis of suspension

Sr.No.	h m	Time for 5 oscillation

CALCULATIONS:

Experimentally, t= (time for 5 oscillations) / 5

Let,

m = Mass of compound Pendulum = 1.07 kg

k = radius of gyration about an axis through c.g. perpendicular to plane of oscillations

Now, Tme eriod, $t = 2\pi\,(k^2 + h^2 / g.h)^{0.5}$ s

Therefore,

$k = \sqrt{(t/2\pi)^2\, g.h - h^2}$

And equivalent length of simple pendulum,

$$L = \frac{(k^2 + h^2)}{h}$$

the equivalent length can be verified by setting the simple pendulum to L

CONCLUSION: The radius of gyration of a compound pendulum = ________

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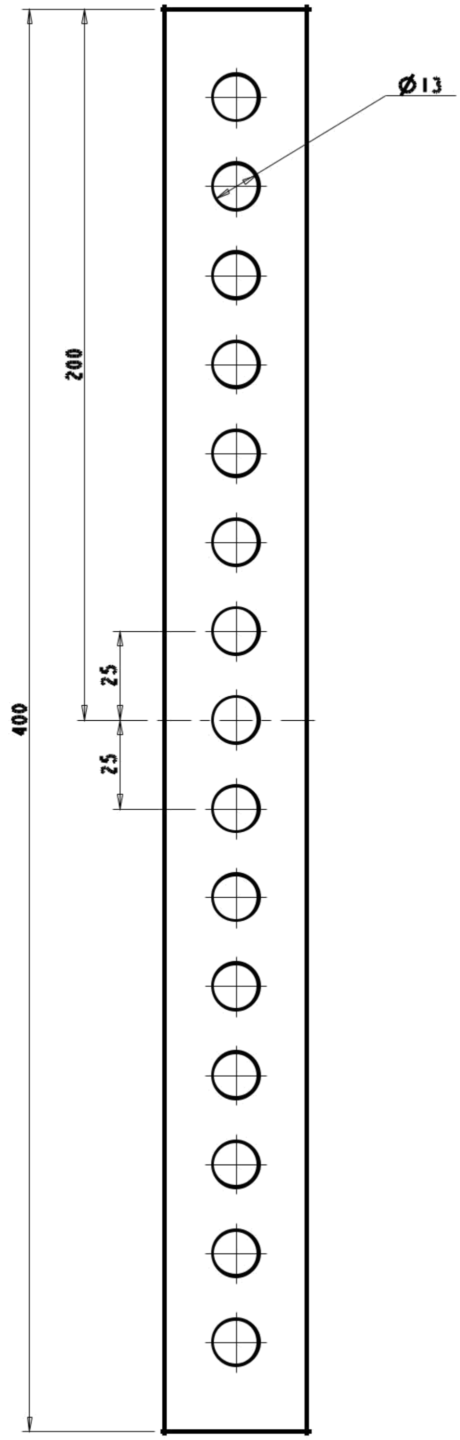
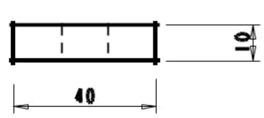
SCALE 0.200





MATERIAL:- MILD STEEL
FLAT BAR 40X10, 400 LG
SCALE 0.500

GENERAL TOLERENCE APPLY AS PER ISO-2768 mk	MECHMATICS	COMPOUND PEDULUM FLAT BAR
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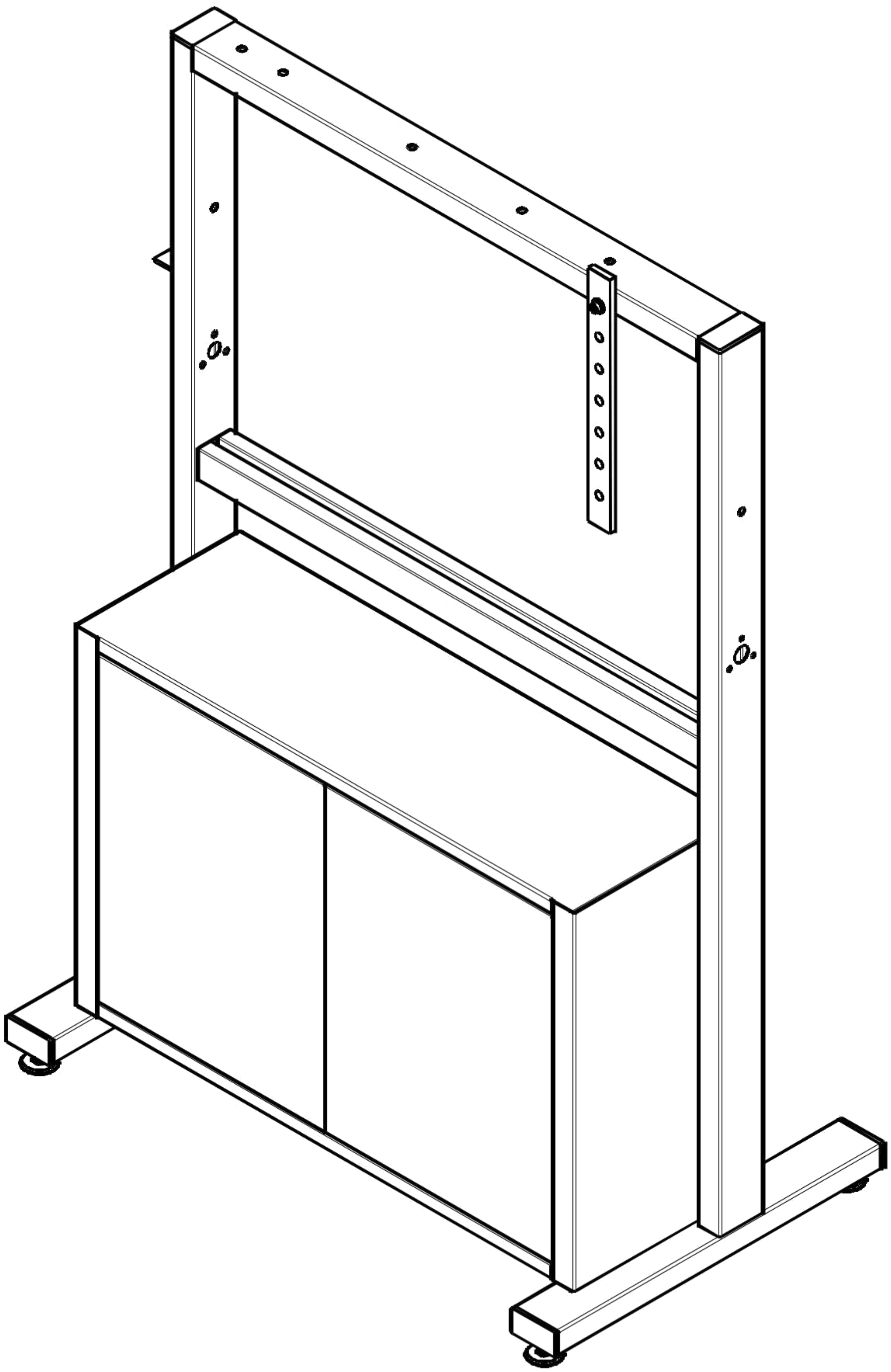

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ALL DIMENSIONS ARE IN MM

SAMPLE CALCULATIONS

Experiment – Compound Pendulum

Observation

Sr. No.	h (m)	Time for 5 Oscillations
1	0.175	5.58

Time Period = 5.58/5 = 1.12 sec

Radius Of Gyration = k = $\{(1.12/2x3.14)^2$ x 9.81x 0.175 – $0.175^2\}^{0.5}$ = 0.155

Equivalent Length = (0. 155^2 + 0.175^2) / 0.175 = 0.3123 m

Time period for Simple pendulum set at length on 31 cm approx = 1.12 sec

Hence Verified

Reference video link:
https://www.youtube.com/watch?v=3uZ_Boyt_AI
https://www.youtube.com/watch?v=vUb25cvHOZ4
https://www.youtube.com/watch?v=kyKLakPkrZE

EXP-3 BIFILAR SUPENSION

AIM

To determine the radius of gyration of a body using bifilar suspension

PROCEDURE

Attach the Bi-filar suspension strings to the hooks at top beam of the frame. Fix the weights required over the beam of bi-filar. Oscillate the system about vertical axis passing through the centre of beam. Measure the time required for 10 oscillations.

Repeat the procedure by changing the length of suspension

OBSERVATIONS

Sr. No.	Length of string L (m)	Distance of weights from the centre 'a'		Time for 10 oscillations 't' sec
		gm	gm	
1				
2				

CALCULATIONS -

For bifilar suspension

$$f_n = \frac{1}{2\pi} \frac{b}{k} \sqrt{\frac{g}{L}}$$

Where, f_n = frequency of oscillation cps
b = Distance of string from centre of gravity = 0.15 m
L = Length of strings, m
k = radius of gyration

Therefore, $k = \frac{b}{2 \cdot \pi \cdot f_n} \cdot (g/L)^{0.5}$

Now,

t_{exp} = Time for 10 oscillations /10 sec

Therefore,

$f_n = \frac{1}{t_{exp}}$ thus, value of 'k' can be determined

For beam,

Radius of gyration, $k_b = \sqrt{\frac{L_b^2}{3} + \frac{h_b^2}{12}}$

Where, $L_b = 0.175m$

$h_b = 0.04m$

when weight are added away from center for each weight radius of gyration

$k_w = \sqrt{a^2 - (r^2/2)}$

where, Distance of weight from beam centre, a = 0.05 or 0.1 m
Radius of weight, r = 0.02m

for the weight at the centre

$$k_w = r / \sqrt{2}$$

where , r = Radius of the weight = 0.02 m

Now, Total moment of inertia of system

$I_T = I_{beam} + I_{weights}$
$= (m_{beam} \times k_b^2) + (m_{w1} \times k^2_{w1} \times n_1) + (m_{w2} \times k^2_{w2} \times n_2) +$ ---

Where, n_1 = no. of weights at k_{w1}
n_2 = no. of weights at k_{w2}

Now, $I_T = m (k_{eff.})2$

Where, k_{eff} = Effective radius of gyration
m = Total mass of this systems
= Mass of beam + Mass of weights

Mass of beam = 0.54 kg

CONCLUSION:

k_{eff} is approximately equal to calculated ‘k’

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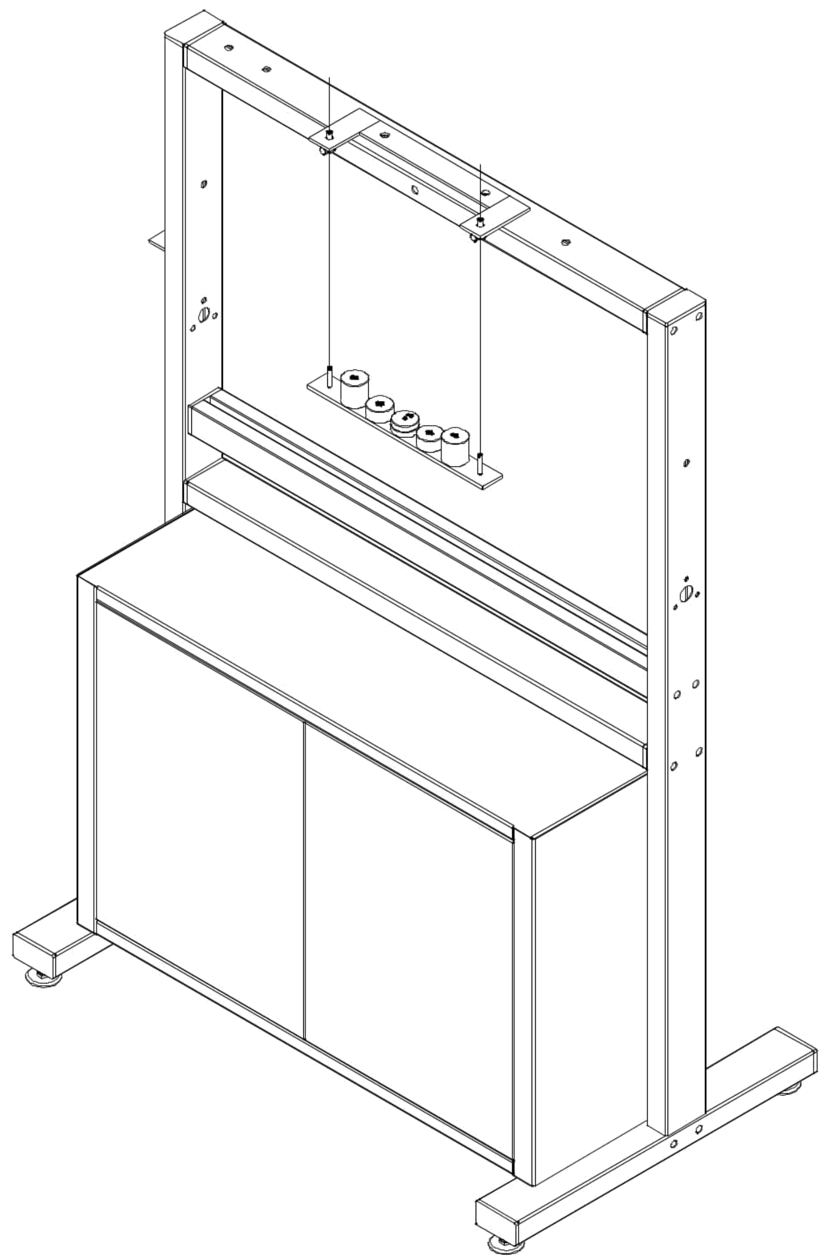

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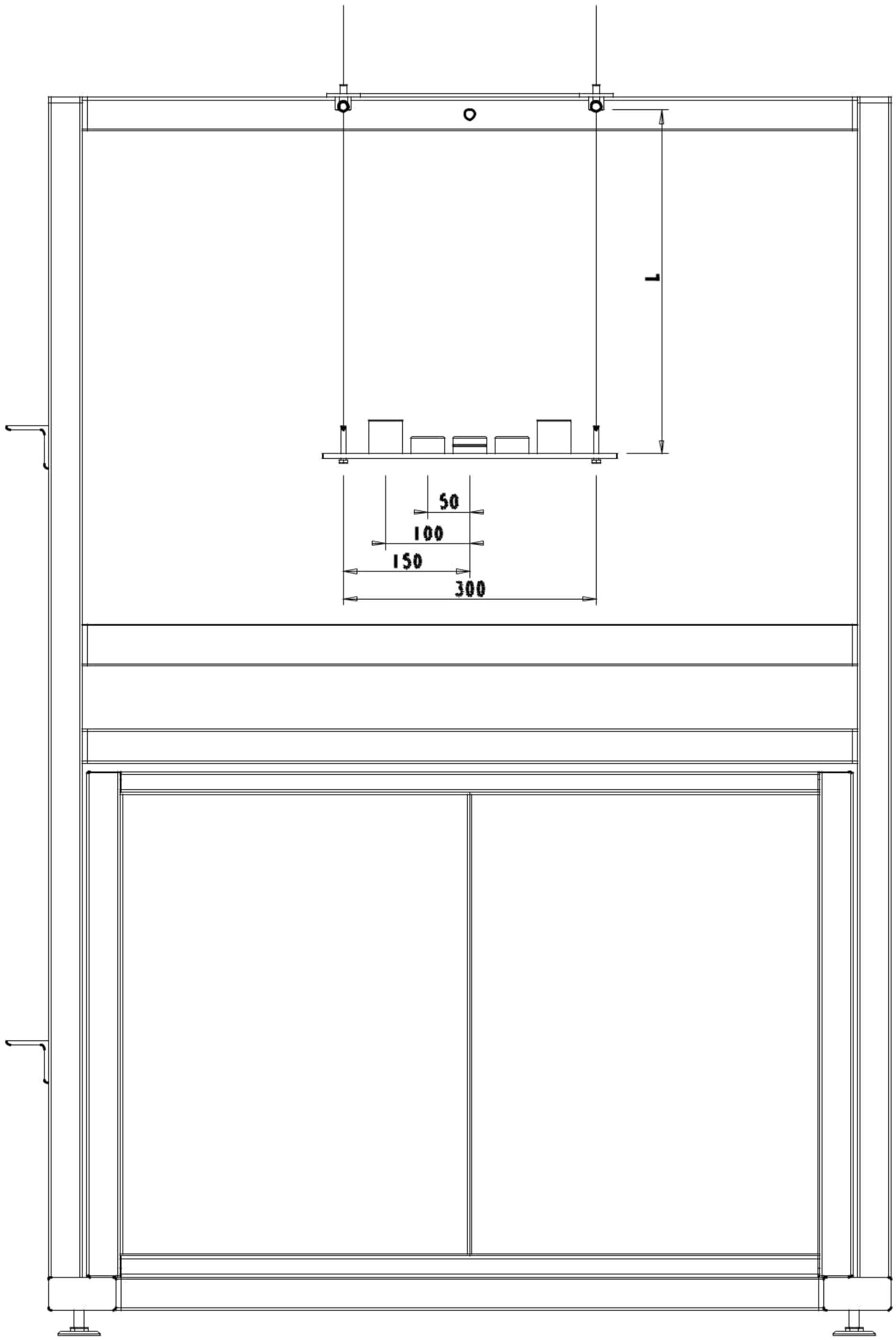

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Sample Calculations

Experiment – Bifilar Suspension

Sr. No.	Length of String	Distance of weights from centre 'a'		Time for 10 oscillations
		200 gm	400 gm	
1	0.280	0.05 (x 2)	0.1 (x 2)	7.18 sec

T_{exp} = 7.18/10 = 0.718 sec
f_n = 1/0.718 = 1.3927 s^{-1}
Therefore

$$K = \frac{0.15 \times (9.81/0.280)^{0.5}}{2 \times 3.14 \times 1.3927} = 0.1015$$

Steps to determine k_{eff}

Radius of gyration Beam =
$k_b = \{(0.175^2/3) + (0.04^2/12)\}^{0.5} = 0.1016$

Radius of gyration 200 gm weight
$K_{w1} = \{0.05^2 - (0.02^2/2)\}^{0.5} = 0.047958315$

Radius of gyration 400 gm weight
$K_{w2} = \{0.1^2 - (0.02^2/2)\}^{0.5} = 0.098994949$

Since weight of 100 gm are attached at center,
$K_{w3} = (0.02/2^{0.5}) = 0.1016$

Total moment of Inertia of System
$I_T = I_{beam} + I_{weights}$
$= (0.552 \times 0.1016^2) + (0.2 \text{ X } 0.048^2 \text{x } 2) + (0.4 \text{ X } 0.099^2 \text{x } 2) + (0.1 \text{ X } 0.1016^2 \text{x } 2)$
$= 0.017276344$

Therefore $k_{eff} = (0.01567/1.825)^{0.5} = 0.094126$

Conclusion:-
K_{eff} is Approximately equal to K

Reference video link:
https://www.youtube.com/watch?v=cEi-fT_KSIM
https://www.youtube.com/watch?v=HrG7xhrLbWo
https://www.youtube.com/watch?v=fMsDcE131R4

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EXP-4 TRIFILAR SUPENSION

AIM:

To determine radius of gyration of disc using Trifilar suspension

PROCEDURE:

Fix the disc with nylon ropes to the hooks on the frame. Oscillate the disc so that it moves about its vertical axis passing through its center. Note down the time required for 10 oscillations. Repeat the procedure by changing the length of ropes.

OBSERVATIONS:

Sr. No.	Length of Rope, ‘L’ m	Time for 10 Oscillations, ‘t’ sec

CALCULATIONS:

t_{exp} = Time for 10 oscillations /10 sec

$f_{exp} = 1/t_{exp}$

For Trifilar suspension

$$f_n = \frac{1}{2\pi} \frac{b}{k_{exp}} \sqrt{\frac{g}{L}}$$

where, b = Distance of rope from centre = 0.1 m

K = Radius of gyration, m

L = Length of String, m

$$k_{exp} = \frac{1}{2\pi} \frac{b}{f_n} \sqrt{\frac{g}{L}}$$

Theoretically, for disc:-

$K = r / \sqrt{2}$

where, r = radius of disc = 0.11 m

CONCLUSIONS:

Radius of Gyration for given disc =

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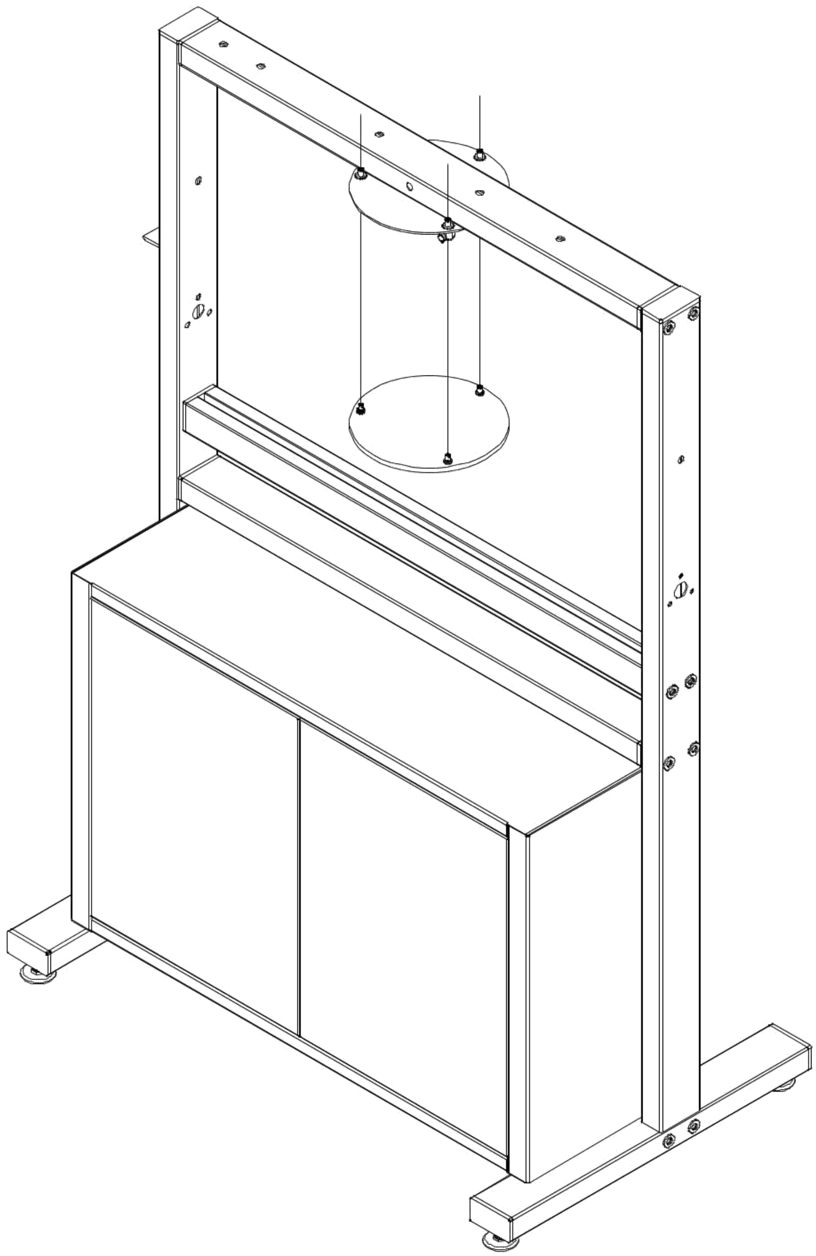

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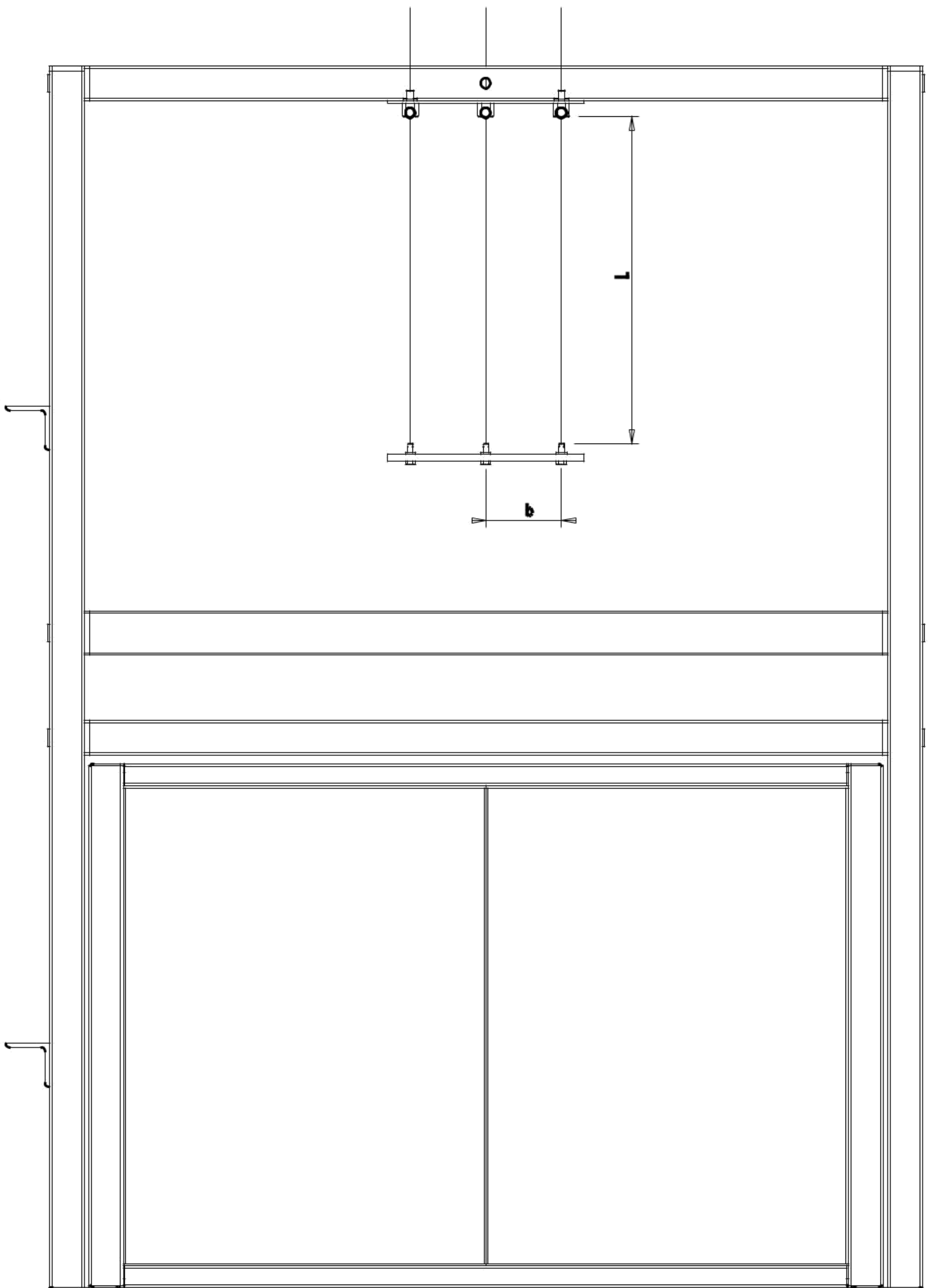

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Sample Calculations

Experiment – Trifilar Suspension

Sr. No.	Length of Rope, 'L' m	Time for 10 Oscillations, 't' sec
1	0.235	8

CALCULATIONS:

t_{exp} = Time for 10 oscillations /10 sec = 0.8
$f_{exp} = 1/t_{exp}$ = 1.25

where, b = Distance of rope from centre = 0.1 m
K = Radius of gyration, m
L = Length of String, m

$$k_{exp} = \frac{1}{2\pi}\,\frac{0.1}{1.25}\sqrt{\frac{9.81}{0.25}} = 0.08232$$

Theoretically, for disc:-

$K = r / \sqrt{2} = 0.078$

where, r = radius of disc = 0.11 m

CONCLUSIONS:
Radius of Gyration for given disc = 0.078

Reference video link:
https://www.youtube.com/watch?v=0GAdMAm1-3o
https://www.youtube.com/watch?v=Avk_3YsowbM
https://www.youtube.com/watch?v=66hAyouz-vg

DOM.	*UNIVERSAL VIBRATION APPARATUS*
	EXP-5 SINGLE ROTOR TORSIONAL VIBRATIONS

AIM:

To study the torsional vibrations of single rotor system

PROCEDURE:

1. Grip one end of the shaft at bracket by the chuck.
2. Fix other end of shaft in the rotor.
3. Measure the Shft length and Diameter
4. Twist the motor rotor to some angle and then release.
5. Note down the time for no. of oscillations.
6. Repeat the procedure for different length of shaft.

OBSERVATIONS:

Sr. No.	Shaft Dia	Shaft length L m	Time for 10 oscillations, t sec

CALCULATIONS:

t_{expt} = (time for 10 oscillations) /10

sec Theoretically,

$$f_n = \frac{1}{2\pi}\sqrt{\frac{C.J}{L.I}}$$

Where, c = modulus of rigidity of shaft = 8.5 x 10^{10} N/m^2

J = Polar moment of inertia = (π /32)d^4 = 7.95 x 10^{-12} = 2.51 x 10^{-11} = 6.13 x 10^{-11} m^4 (dia = 3 mm) m^4 (dia = 4 mm) m^4 (dia = 5 mm)

L = Length of shaft m &

I =Mass moment of inertia of disc = m.k^2 = 0.0375 kg m^2 Where, m = Mass of disc = 7.5 kg

k = Radius of gyration of disc = 0.0707 m

t_{theo} = 1 / f_n sec

CONCLUSION

$$\text{Frequency} \propto \frac{1}{\text{Length of shaft}}$$

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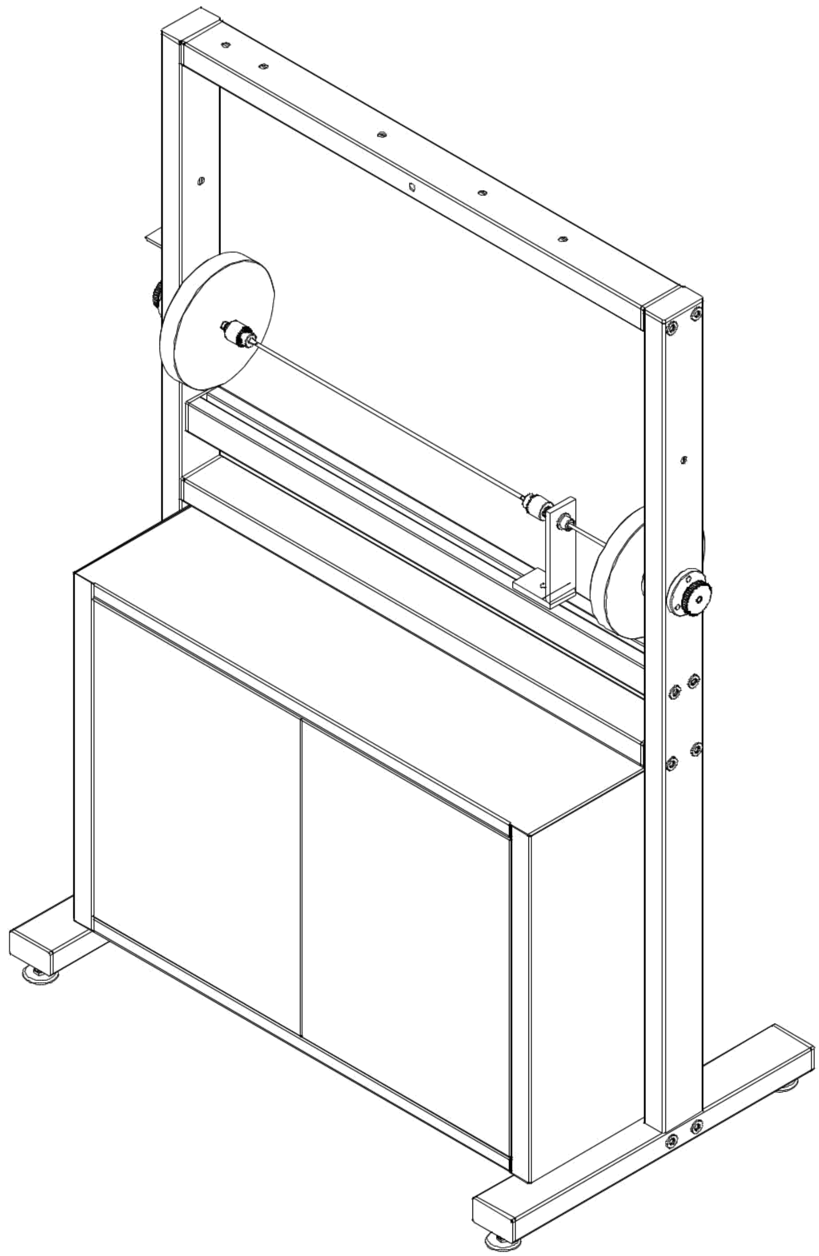

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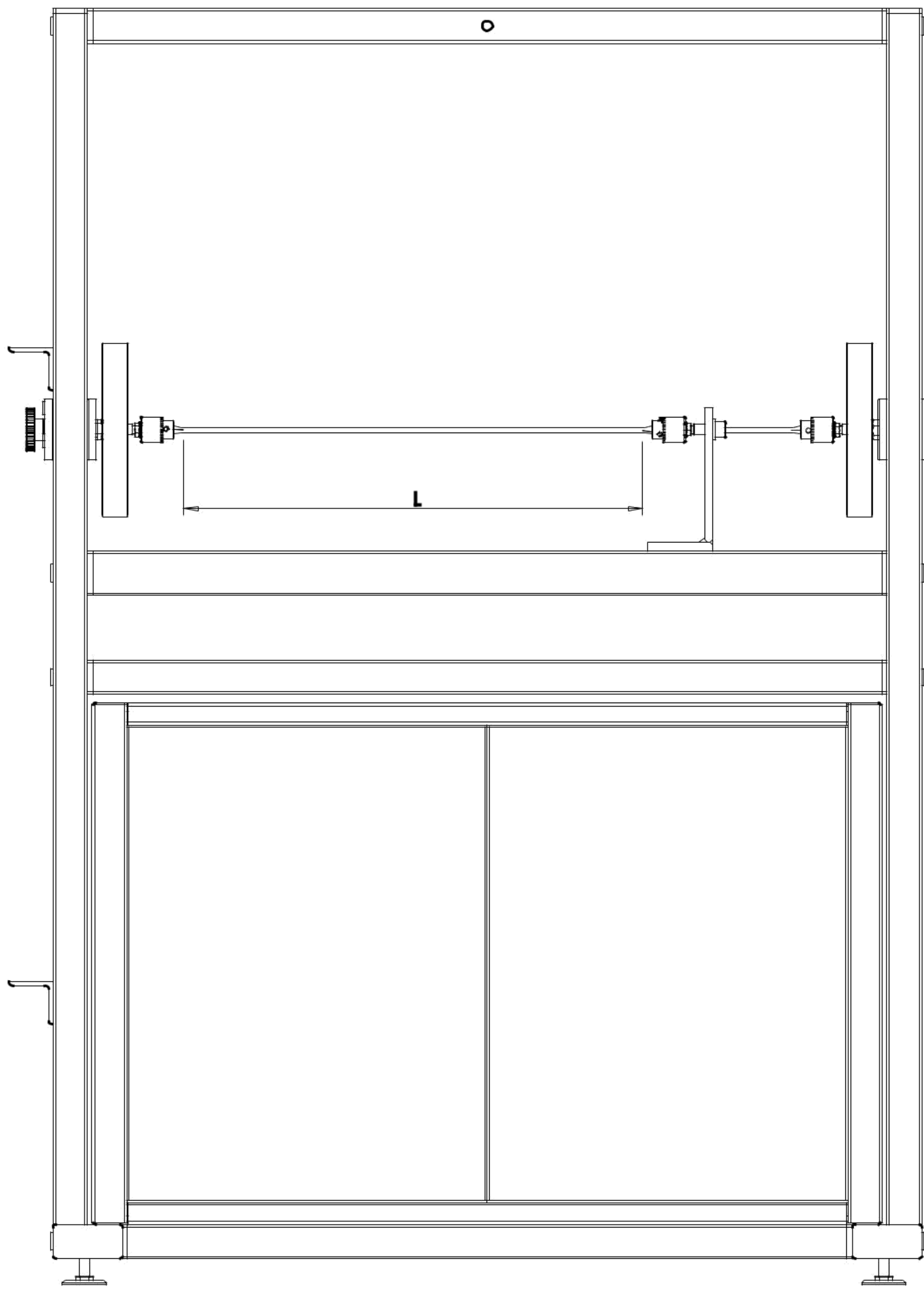

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Sample Calculations

Experiment – Single Rotor System

Sr. No.	Shaft Length L m	Time for 10 oscillations
1	0.45	4.3

t_{exp} = 4.3/10 = 0.43

Now Theoretically,

$$F = \frac{1}{2 \text{ X } 3.14} \left\{ \frac{8.5 \text{ x } 10^{10} \text{ x } 7.95 \text{ x } 10^{-12}}{0.45 \text{ X } 0.0375} \right\}^{0.5}$$

= 2.79

t_{theo} = 0.36

Hence Verified

Reference video link:
https://www.youtube.com/watch?v=gj9UcsoXYQI
https://www.youtube.com/watch?v=dRkJuVh9hF0
https://www.youtube.com/watch?v=ICDZ5uLGrI4

DOM.	UNIVERSAL VIBRATION APPARATUS **EXP-6 TWO ROTOR TORSIONAL VIBRATIONS**

AIM

To study the torsional vibrations of two rotor system

PROCEDURE

1. Fix two disc of the shaft and fit the shaft in the bearing.
2. Deflect the disc in opposite direction by hand and then release.
3. Note down the time required for particular number of oscillations.
4. Repeat the procedure with different diameter shafts and note down the time.

OBSERVATIONS

Sr. No.	Shaft Dia	Shaft length L m	Time for 10 oscillations, t sec

Mass of Rotor = 7.5 kg

Dia of Rotor = 0.2 m

Therefore, $I_a = m_a \cdot k^2 = m \times (r_a^2 / \sqrt{2}) = 0.0375\ kg\ m^2$

Node point, $L_a = L/2$ Since both rotors are of same mass

Therefore,

$$t = 2\pi\ L_a \sqrt{\frac{I_a}{C \cdot J}}$$

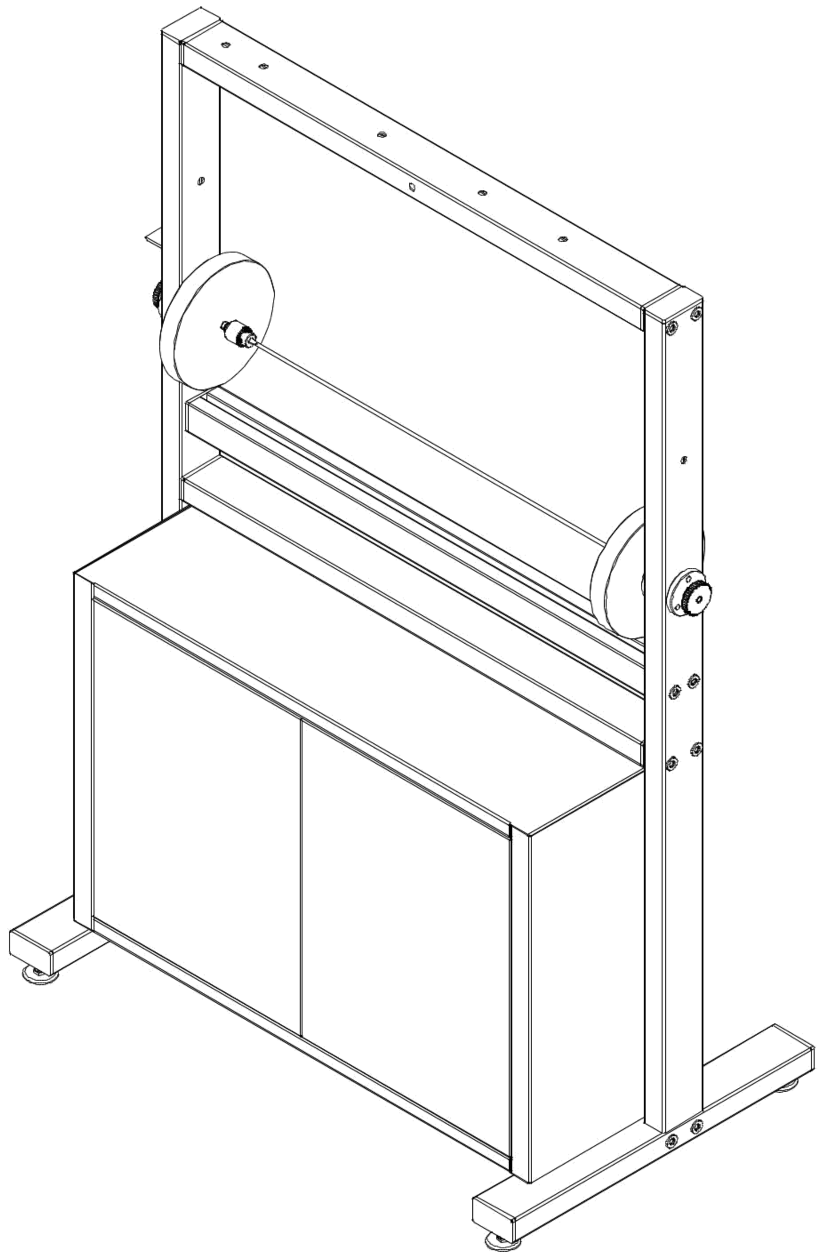
Where, C = Modulus of Rigidity = $8.5 \times 10^{10}\ N/m^2$

Polar moment of inertia = $(\pi /32)$ $^4 = 7.95 \times 10^{-12}\ m^4$ (dia = 3 mm)

$= 2.51 \times 10^{-11}\ m^4$ (dia = 4 mm)

$= 6.13 \times 10^{-11}\ m^4$ (dia = 5 mm)

REVISIONS				
ZONE	REV	DESCRIPTION	DATE	APPROVED



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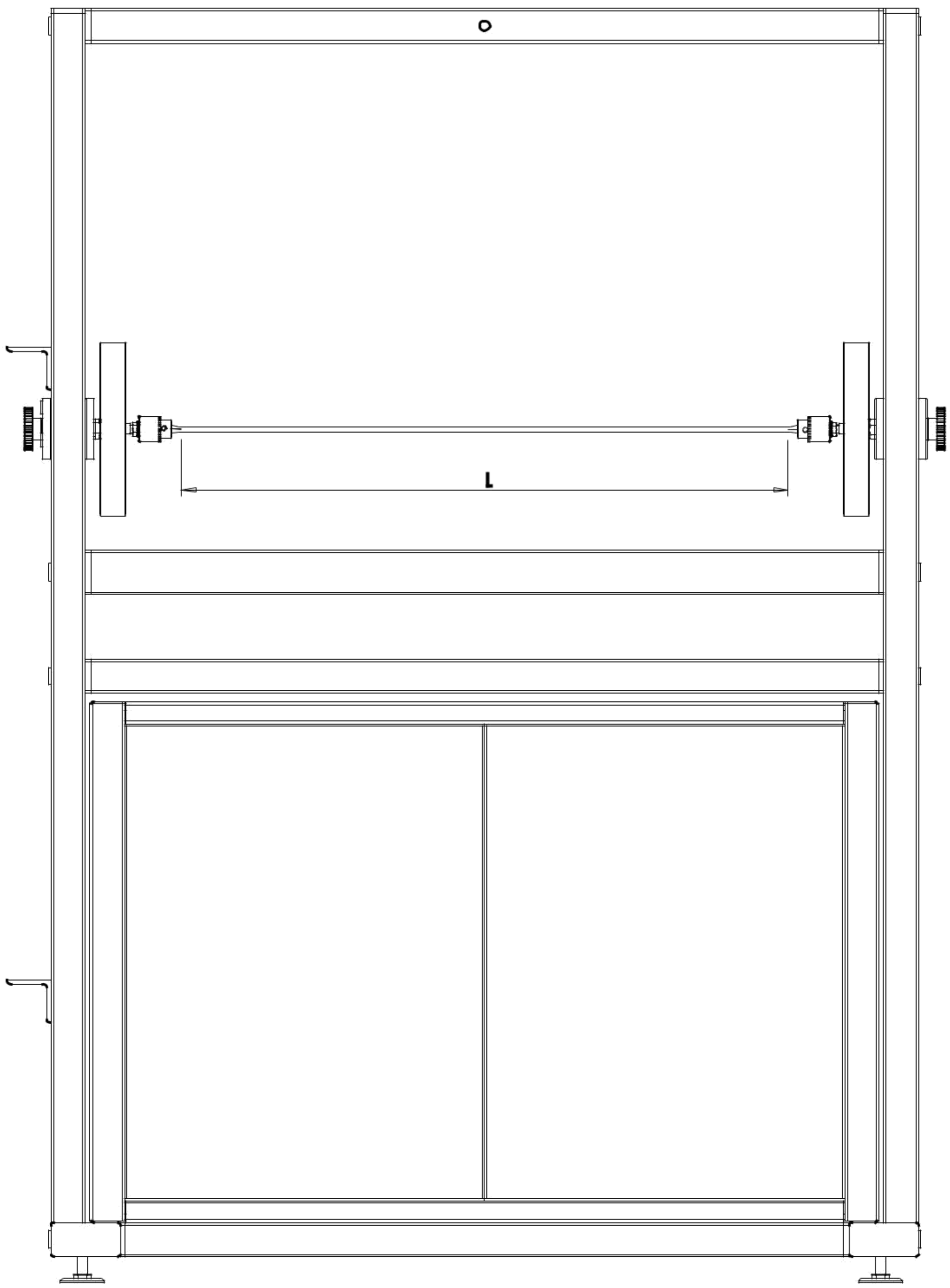

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Sample Calculations

Experiment – Torsional Vibration of Two Rotor

Sr. No.	Shaft Length L m	Time for 10 oscillations
1	0.71	4.02

t_{exp} = 4.02/10 = 0.402

Now Theoretically,

Since both rotor here of equal mass node point = L_a = 0.71/2 = 0.355

I_a = 0.0375

$$t_{theo} = 2 \text{ X } 3.14 \left\{ \frac{0.355 \text{ X } 0.0375}{8.5 \times 10^{10} \times 6.13 \times 10^{-12}} \right\}^{0.5}$$

t_{theo} = 0.315

Hence Verified

Reference video link:
https://www.youtube.com/watch?v=HMk3fM_MYnw
https://www.youtube.com/watch?v=FjaRlosNH60
https://www.youtube.com/watch?v=dRkJuVh9hF0&t=42s

DOM.	*UNIVERSAL VIBRATION APPARATUS* ***EXP-7 DAMPED TORSIONAL VIBRATIONS***

AIM To study damped torsional vibrations of single rotor system.

PROCEDURE

1. Put thin mineral oil in the drum and note the depth of immersion.
2. Put the sketching pen in the Dipper.
3. Allow the flywheel to vibrate.
4. Allow the pen to descend and see that it is in contact with the paper.
5. Measure the time for some oscillations by means of stop watch
6. Determine amplitude (X_1) at any position and amplitude(X_2) after successive time interval

OBSERVATIONS

Damping fluid-

Sr. No.	Length of the Shaft, m	Depth of immersion of shaft, mm	X_1	X_2

CALCULATIONS

Let x_1 & x_2 be amplitudes at successive time intervals t_1 and t_2.

Then, logarithmic decrement, $\delta = \log_e (x_1 / x_2)$

As damping is very small (λ <<

1) $\delta = 2\pi\lambda$

Where, λ = damping factor

Determine from λ from δ

Plot the graph of δ vs. Depth of immersion.

Also, plot the graph of δ vs. λ

REVISIONS				
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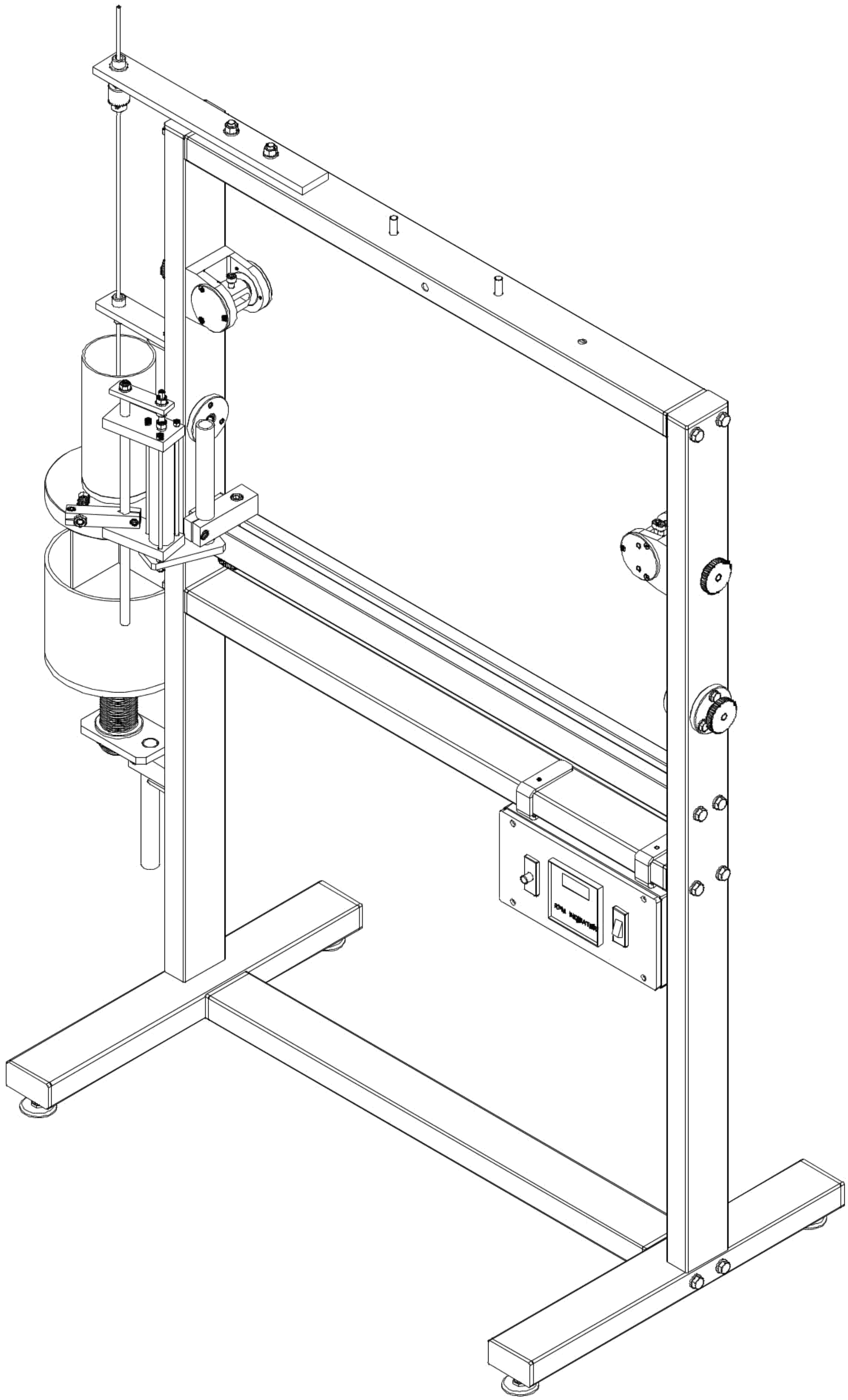

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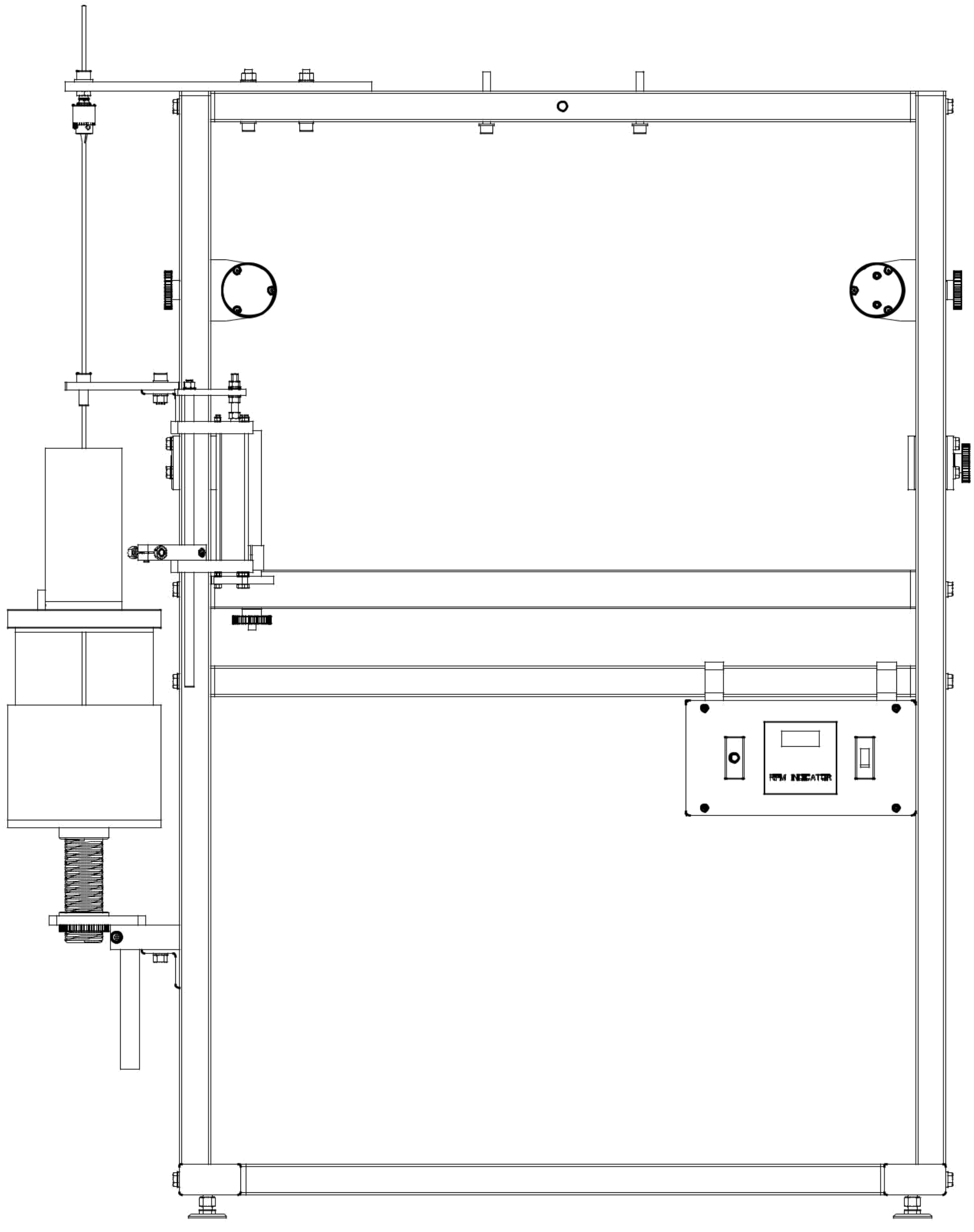
		VB00-0000 -

REVISIONS				
ZONE	REV	DESCRIPTION	DATE	APPROVED



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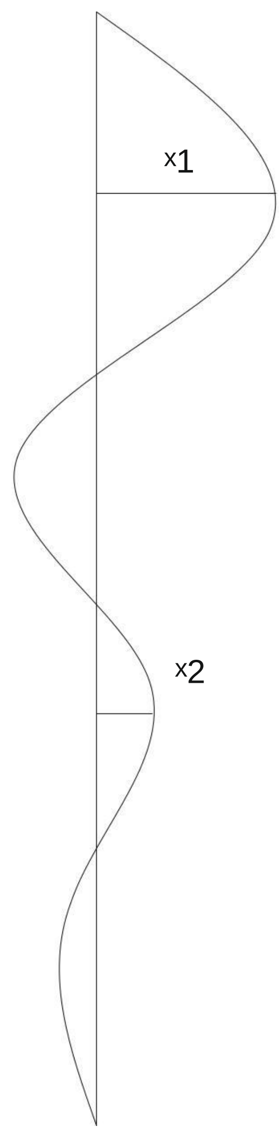
Sample Plot at Certain Depth of Immersion



Reference video link:

https://www.youtube.com/watch?v=pcmLp4pSrKM
https://www.youtube.com/watch?v=Z0pIdW9NJIU
https://www.youtube.com/watch?v=bX_m53Xexvk&list=PL1A420F98BA2DEA22

EXP-8 HELICAL SPRING FREE VIBRATIONS

AIM To study undamped free vibrations of a spring.

PROCEDURE

1. Fix one end of the helical spring to upper screw and holder at the other end.
2. Determine the straight length of the helical spring at no load.
3. Put the known weight on the holder. And measure the deflection.
4. For oscillations, Stretch the spring for some distance and leave it.
5. Count the time for no. of oscillations.
6. Determine the actual time period.
7. Repeat the same procedure for different weights.

OBSERVATIONS

Weight of the holder: 0.240 kg
Weight of mass : 0.760 kg

Sr. No.	Attached mass, m kg	Deflection, mtr	Time for 10 oscillations, t sec

CALCULATIONS-

Spring deflection, δ = m

Weight attached, w = mg N

Stiffness of spring, k = $\frac{w}{\delta}$ N

Frequency of oscillations,

$f_n = \frac{1}{2\pi}\sqrt{\frac{k}{m}}$ Hz

Therefore

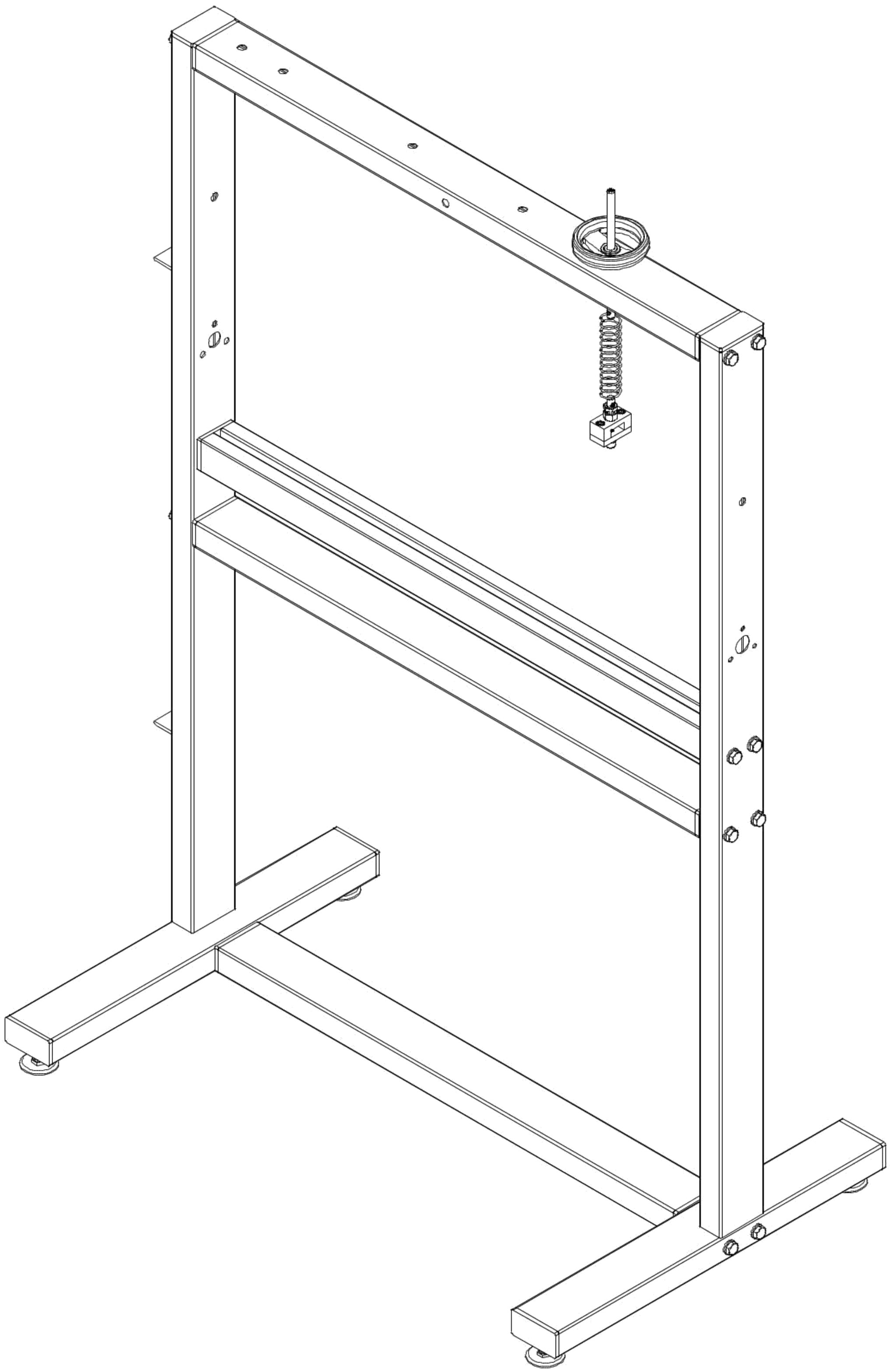
$t = 2\pi \sqrt{m / k}$ sec

Experimentally, t = Time for 10 oscillations / 10

CONCLUSION

1. Stiffness of spring, $k = w/\delta$
2. For free vibration, $f_n = 1/2\pi \sqrt{(k/m)}$ sec

REVISIONS				
ZONE	REV	DESCRIPTION	DATE	APPROVED



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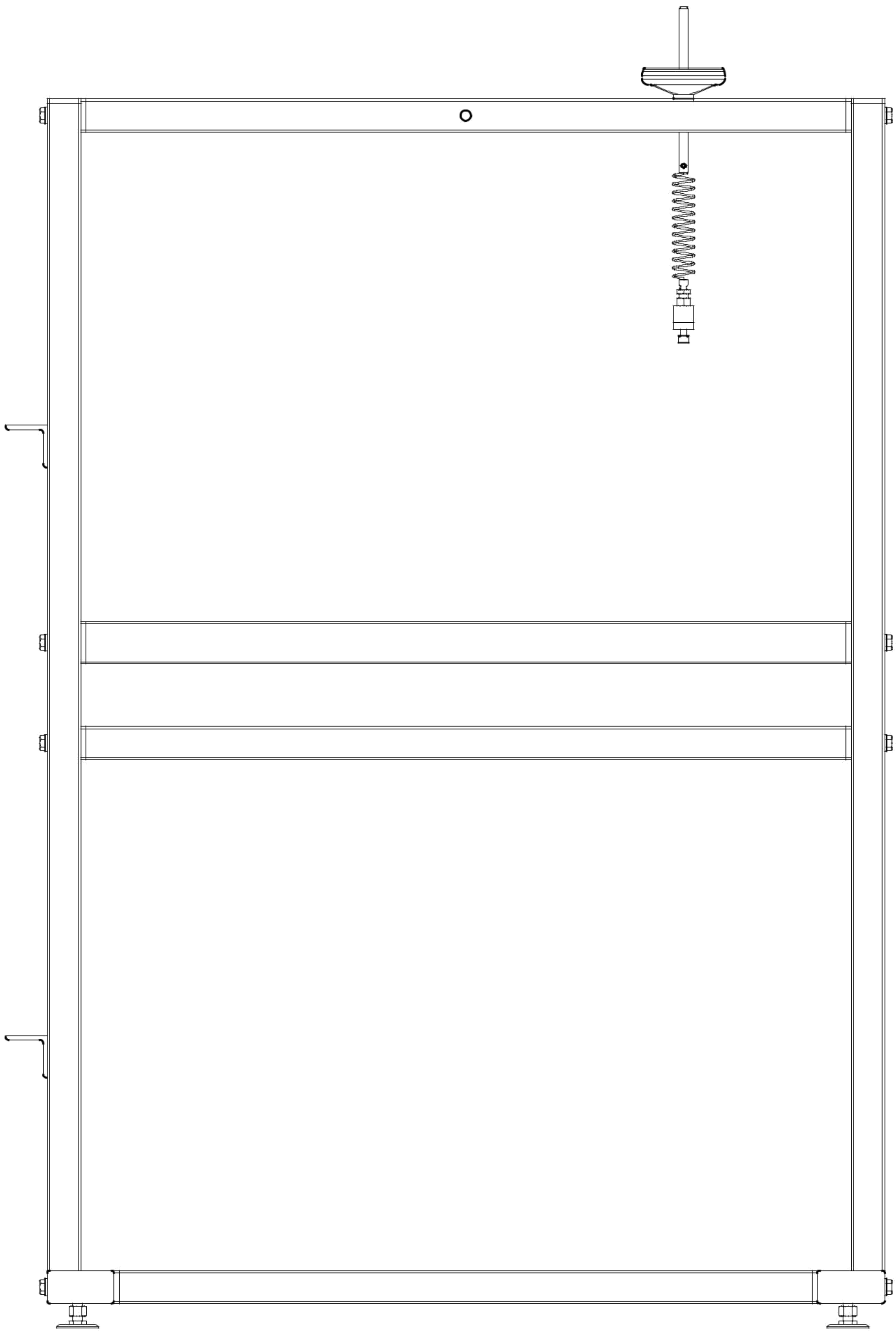

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SPRING STIFFNESS CHART

Sr. No.	Dia	Initial Length	Final length	Weight Attached	Stiffness	T(Theo)	Time for 15 oscialltion	T(Practical)	% Error
	in mm	in mm	in mm	in gms	in N/m	sec	sec	sec	%
1	0.70	61.83	600.15	300.00	5.47	1.47	22.61	1.51	2.46
2	0.80	62.11	334.12	300.00	10.82	1.05	16.04	1.07	2.26
3	1.00	60.53	309.14	800.00	31.57	1.00	15.28	1.02	1.89
4	1.20	62.51	289.22	800.00	34.62	0.95	14.52	0.97	1.39
5	1.70	59.55	114.48	2300.00	410.76	0.47	7.13	0.48	1.15

Reference video link:

https://www.youtube.com/watch?v=f2wGE_n5xtA
https://www.youtube.com/watch?v=HRcjtVa1LfM
https://www.youtube.com/watch?v=nDr_ozIe5AU

EXP-9 EQUVIVALENT SPRING STIFFNESS

AIM To calculate equivalent spring stiffness for spings in series.

PROCEDURE

1. Take two spring of known stiffness and attach in series
2. Fix one end of the series spring to upper screw and holder at the other end.
3. Determine the straight length of the helical spring at no load.
4. Put the known weight on the holder. And measure the deflection.
5. For oscillations, Stretch the spring for some distance and leave it.
6. Count the time for no. of oscillations.
7. Determine the actual time period.
8. Repeat the same procedure for different weights.

OBSERVATIONS

Weight of the holder: 0.240 kg
Weight of mass : 0.760 kg
Spring Stiffness k_1 =
Spring Stiffness k_2 =

Sr. No.	Attached mass, m kg	Deflection m	Time for 10 oscillations, t sec

CALCULATIONS-

Series spring deflection, δ = m

Weight attached, w = mg N

Equivalent Stiffness of spring, k = $\frac{w}{\delta}$ N

Theortically
Stiffness of spring, $1/k = 1/k_1 + 1/k_2$

CONCLUSION

Eqvivalent Stiffness of spring in series, k =
Theortically Eqvivalent spring stiffness, k =

Sample Calculation Experiment - EQUVIVALENT SPRING STIFFNESS

Sr. No.	Attached mass, m kg	Deflection m	Time for 10 oscillations, t sec
1	1.035	0.108	7.1

CALCULATIONS -

Spring 1)

Series spring deflection, δ = 0.108 m

Weight attached, w = 1.035*9.81 = 10.15335 N

Equivalent Stiffness of spring, k = $\frac{w}{\delta}$ = 94.015 N

Theortically ,

Stiffness of spring, $1/k = 1/k_1 + 1/k_2$

$= 1/338 + 1/127$

$= 91.8$ N

Reference video link:

https://www.youtube.com/watch?v=Py7qnXtMIUA

https://www.youtube.com/watch?v=kuKP18TmGJ4

https://www.youtube.com/watch?v=esrtUrjhGX0

EXP-10 NATURAL VIBRATION SPRING MASS SYSTEM

AIM- To study the natural vibrations of a spring mass system

PROCEDURE -

1) Attach one end of the beam to trunion and other to Spring holder as shown in figure.
2) Put exciter in middle and measure the distance from trunion
3) Give a slight jerk and measure time for 10 Oscillations

OBSERVATION-

Spring Stiffness:-

Sr. No.	Exciter position m	Spring Stiffness, N/m	Time for 10 oscillations, t sec

CALCULATIONS -

Mass of Beam = 0.498 kg (3 mm)
= 1.030 kg (6 mm)
= 1.316 kg (8 mm)

Length of Beam = 0.835 m

Let the adjusted length of the beam be L` m
Mass of beam is acting at centre i.e. at (L`/2) m

Let exciter be at 'L' meter from trunion
Therefore, equivalent weight at beam center, producing same moment about trunion center can be written as,

$m \times L = m_1 \times (L`/2)$

$m_1 = m \times L / (L`/2)$

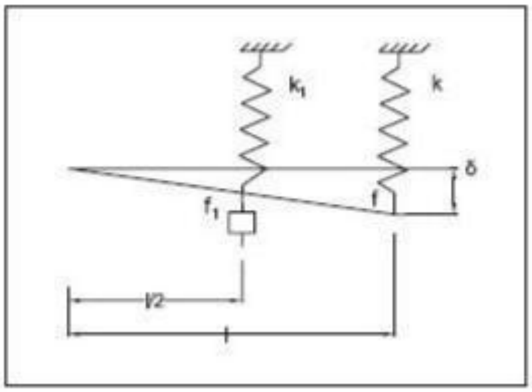
where, m = mass of exciter=4.680 kg

m_1 = Equivalent weight at center

Therefore, total mass acting at beam center

$m_2 = m_1 + m\grave{}$ kg (i.e., m` = Mass of the beam per m x L`)

If the spring is replaced by another spring of stiffness ‘k_1’ acting at centre of the beam,



In the above fig, ‘f’ is the force acting at distances *‘l’* on the spring of stiffness ‘k’ Now,

$$f = k.\,\delta$$

$$f \times l = f_1 \times l/2$$

$$f_1 = 2.\,f$$

also $\quad 2.f = k_1 \,.\, \delta/2$

or $\quad 2k\delta = k_1 \,.\, \delta/2$

$$k_1 = 4k \text{ N/m}$$

$$f_n = \frac{1}{2\pi}\sqrt{\frac{k_1}{m_2}} \quad \text{Hz}$$

Therefore

$$t = 1/f_n \text{ sec}$$

T_{expt} = time for 10 oscillations / 10

CONCLUSION: $f_{n\,(calculated)} = f_{n\,(expt)}$ (approx)

REVISIONS				
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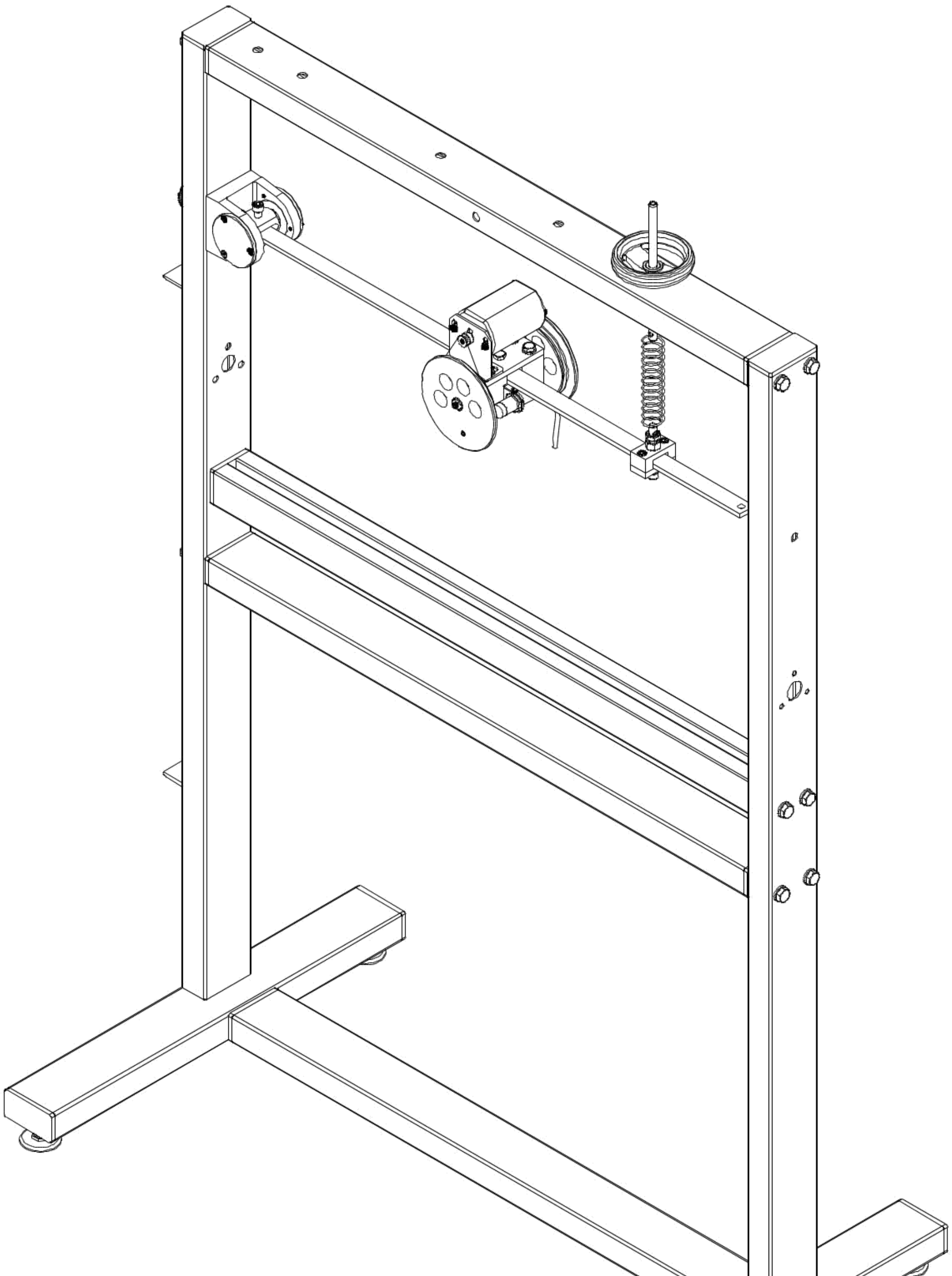

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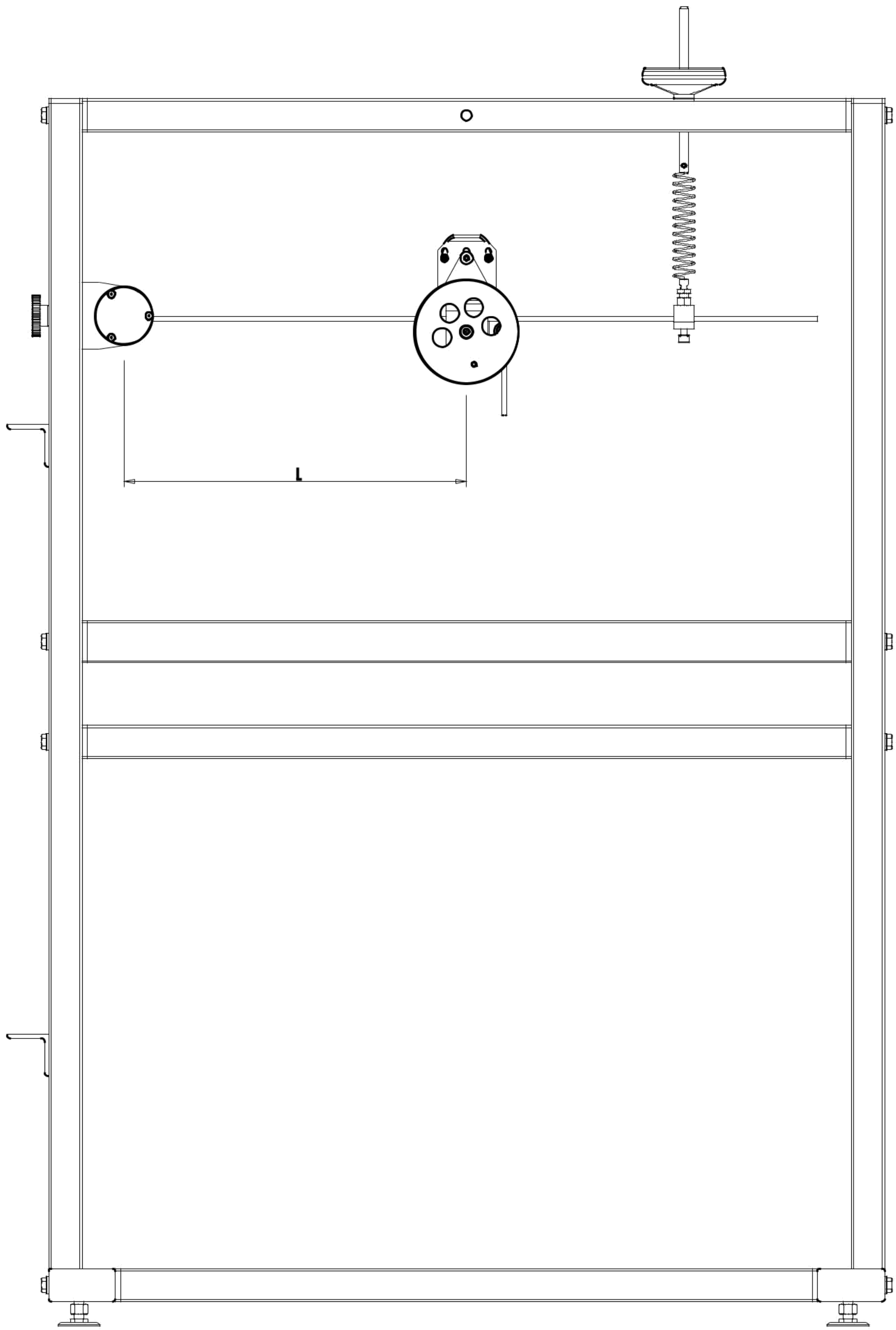

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Sample Calculation Experiment - Spring Mass System

Sr. No.	Exciter position m	Spring Stiffness, N/m	Time for 10 oscillations, t sec
1	0.430	338	4.2

CALCULATIONS -

Mass of Beam = 0.91 kg/m (thick 6 mm)

Length of Beam = 0.830 m

Mass of beam is acting at centre i.e. at 0.415m

Let exciter be at 'L' meter from trunion

Therefore, equivalent weight at beam center, producing same moment about trunion center can be written as,

$m \times L = m_1 \times 0.415$

$m_1 = m \times L / 0.415$

$= 4.615 \text{ X } 0.430/0.418 = 4.780$ kg

where, m = mass of exciter = 4.615 kg

m_1 = Equivalent weight at center

Therefore, total mass acting at beam center

$m_2 = m_1 + 0.7553$ kg (i.e., Mass of the beam = 0.830 x .91 kg) = 5.537 kg

If the spring is replaced by another spring of stiffness 'k_1' acting at centre of the beam,

then $k_1 = 4k$ N/m = 1352 N/m

$$f_n = \frac{1}{2\pi}\sqrt{\frac{k_1}{m_2}} = 2.488 \text{ Hz}$$

Therefore

$t = 1/ f_n$ sec = 0.4018

T_{expt} = time for 10 oscillations / 10 = 0.42

CONCLUSION: $f_{n\,(calculated)} = f_{n\,(expt)}$ (approx)

Reference video link:

https://www.youtube.com/watch?v=r_ouYEYhR5U

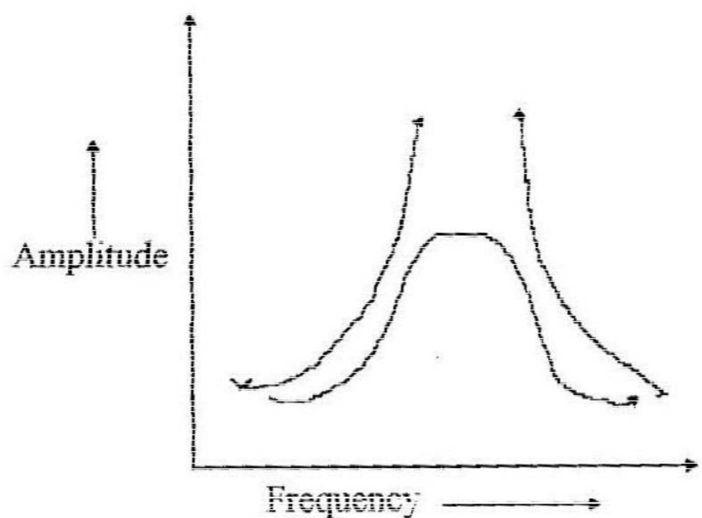
https://www.youtube.com/watch?v=zG-JNm0lsnw

https://www.youtube.com/watch?v=zG-JNm0lsnw

EXP-11 FORCED DAMPED VIBRATIONS OF SPRING MASS SYSTEM

AIM- To study forced damped vibration of a spring mass system.

PROCEDURE- Attach the vibration recorder at suitable position, so that pen clamped to the paper. Attach the damper unit to stud as shown in figure. Set the damper at minimum damping position. Start the vibration recorder. Start the exciter motor and set it at a required speed. Vibrations are recorded over vibration recorder. Increase the speed and again let the vibrations be noted. Take few readings at speeds higher than resonance speed. Go on noting down the frequency on recorded vibrations. Increase the damping and again repeat the experiment. As damping is increased, amplitude of vibrations is reduces. Plot the graph of amplitude V/s. frequency.



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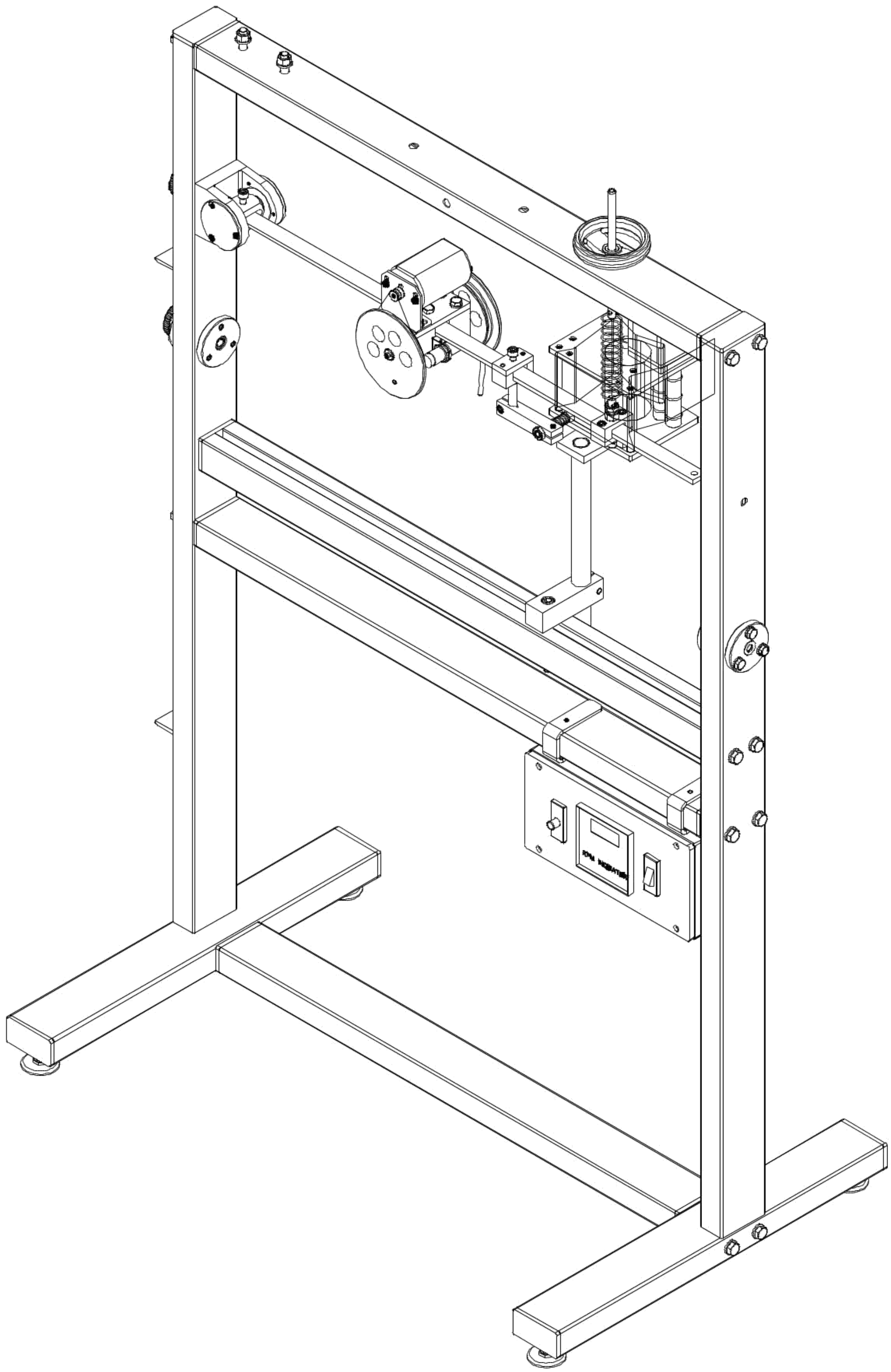

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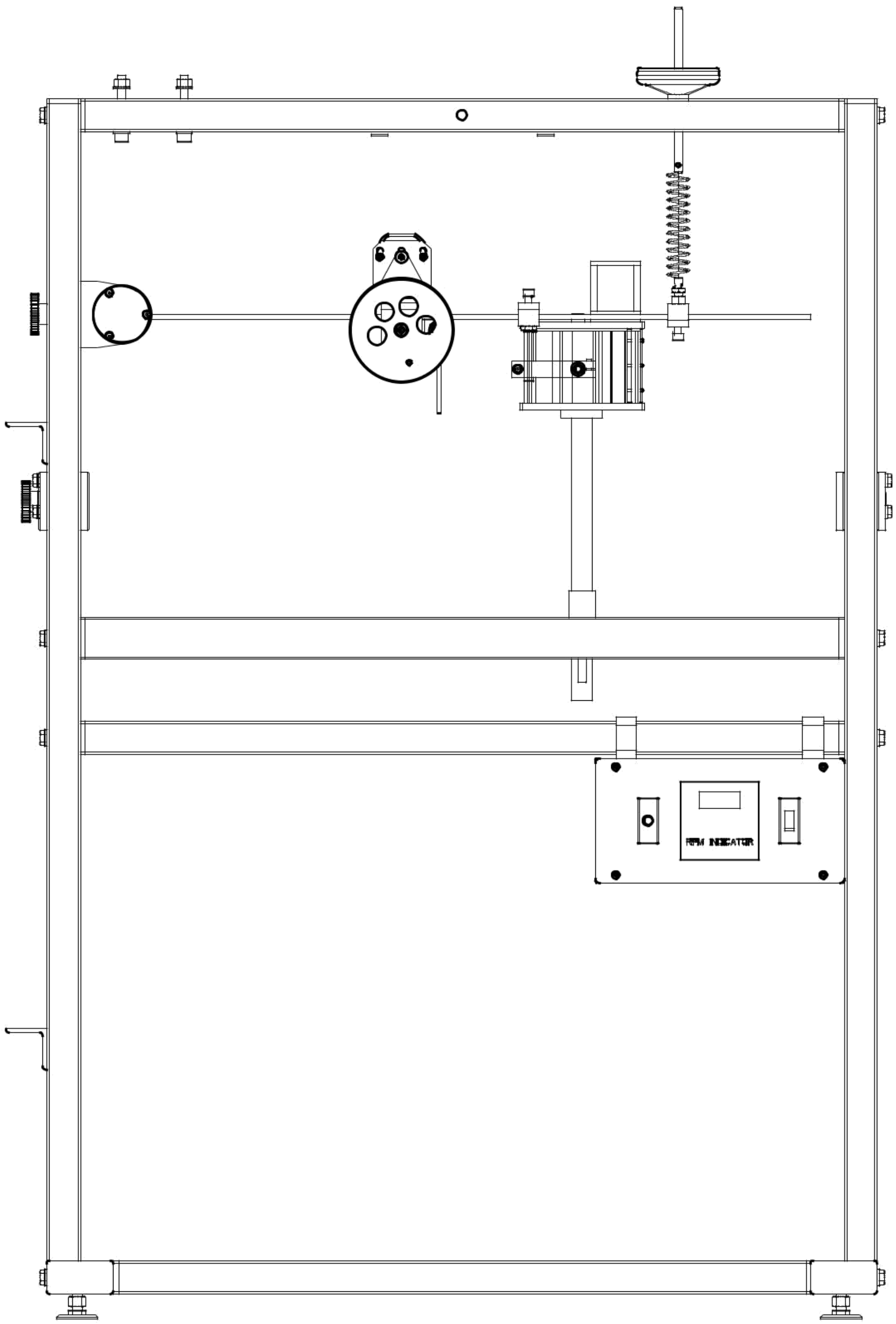

GENERAL TOLERENCE APPLY AS PER ISO-2768 mk	MECHMATICS	DESCRIPTION: 49	
		MODEL NAME: 49	-

EXP-12 DUNKERELY'S RULE VERIFICATION

AIM:- To verify Dunkerely's rule for transverse vibrations

PROCEDURE:- Fix the flat beam between the two trunion brackets. Fix the required weight to the stud and tighten with the help of nut. Set the thin beam vibrating by gentle stroke and measure the time required for 10 oscillations

OBSERVATIONS:-

Sr. No.	Length of beam, m	Weight w_1	Weight w_2	a_1	a_2	Time for 10 Oscillations

Note:- Speed of paper roller is 610 mm / 10 sec (or 610 mm over the paper roll corresponds to 10 sec)

CALCULATIONS

$t_{expt.}$ = time for 10 oscillations/10

Theoretically, by Dunkerley's equation

$$1/f_n^2 = 1/f^2{}_{n_1} + 1/f^2{}_{n_2} + \text{-------} + 1/f^2{}_{n_s}$$

Where,
f_n = frequency of transverse vibration of system = 1/ t
f_{n1}, f_{n2} = frequency of vibrations with m_1, m_2 weights,
f_{ns} = frequency of transverse of vibrations beam under its own weight $f_{n1} = 0.4987 / \sqrt{\delta_1}$ (when is in m)

where,
δ_1 = Deflection due to weight m_1

$= (m \cdot g \cdot a^2 \cdot b^2) / (3 \times E \times I \times L)$

m Where,

m = Weight, kg

a + b = L = Length of beam

$g = 9.81\ m/sec^2$

$E = 27 \times 10^5$ bar $= 27 \times 10^5 \times 10^5\ N/m^2$

$I = (1/12) \times bd^3$ (Since b = 25 mm; d = 6 mm)

$= 4.5 \times 10^{-10}\ m^4$

$f_{ns} = 0.5987 / \sqrt{\delta s}$ (when is in m)

where δs = deflection due to weight of beam, =

$(5 \times w \times L^4) / (384 \times E.I)$

Where,

W = Uniformly distributed load (thin beam weight) = 11.18 N/m

CONCLUSION

T_{expt} =

T_{theo} =

REVISIONS				
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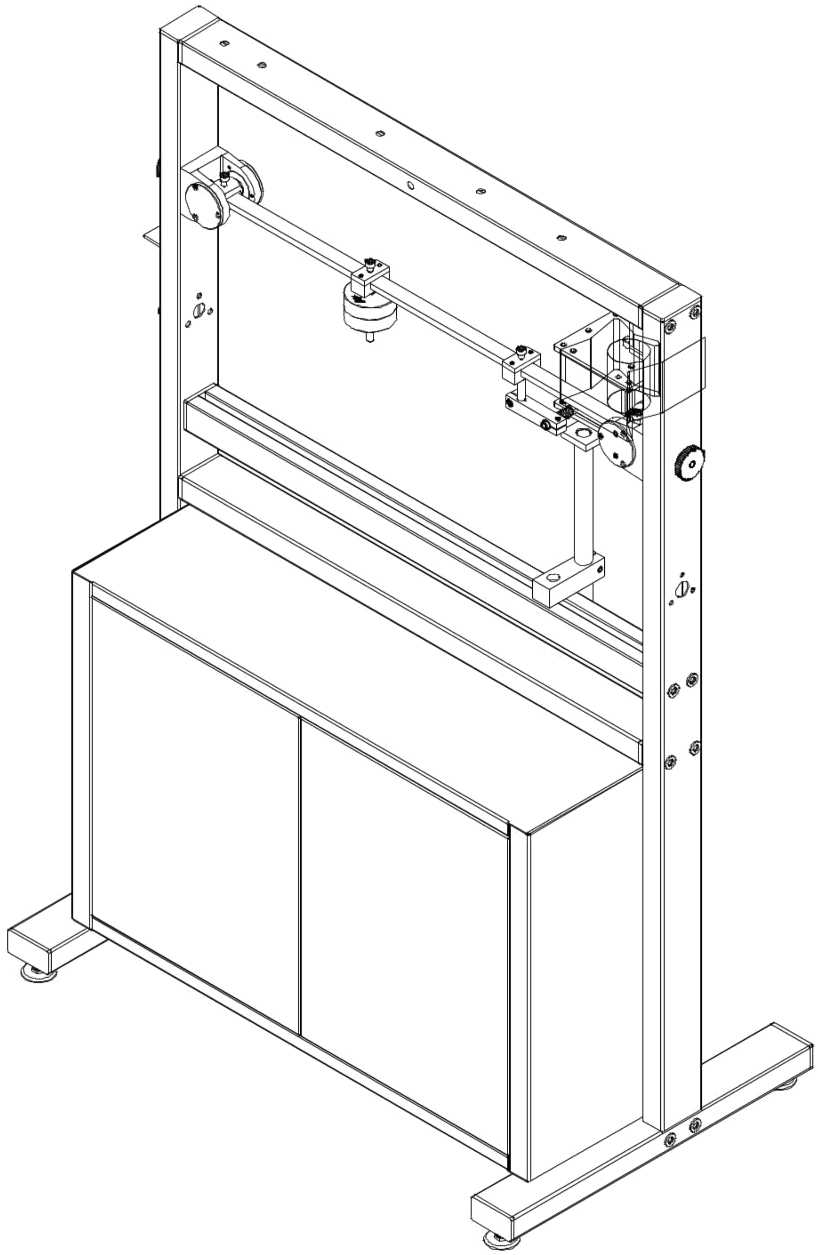

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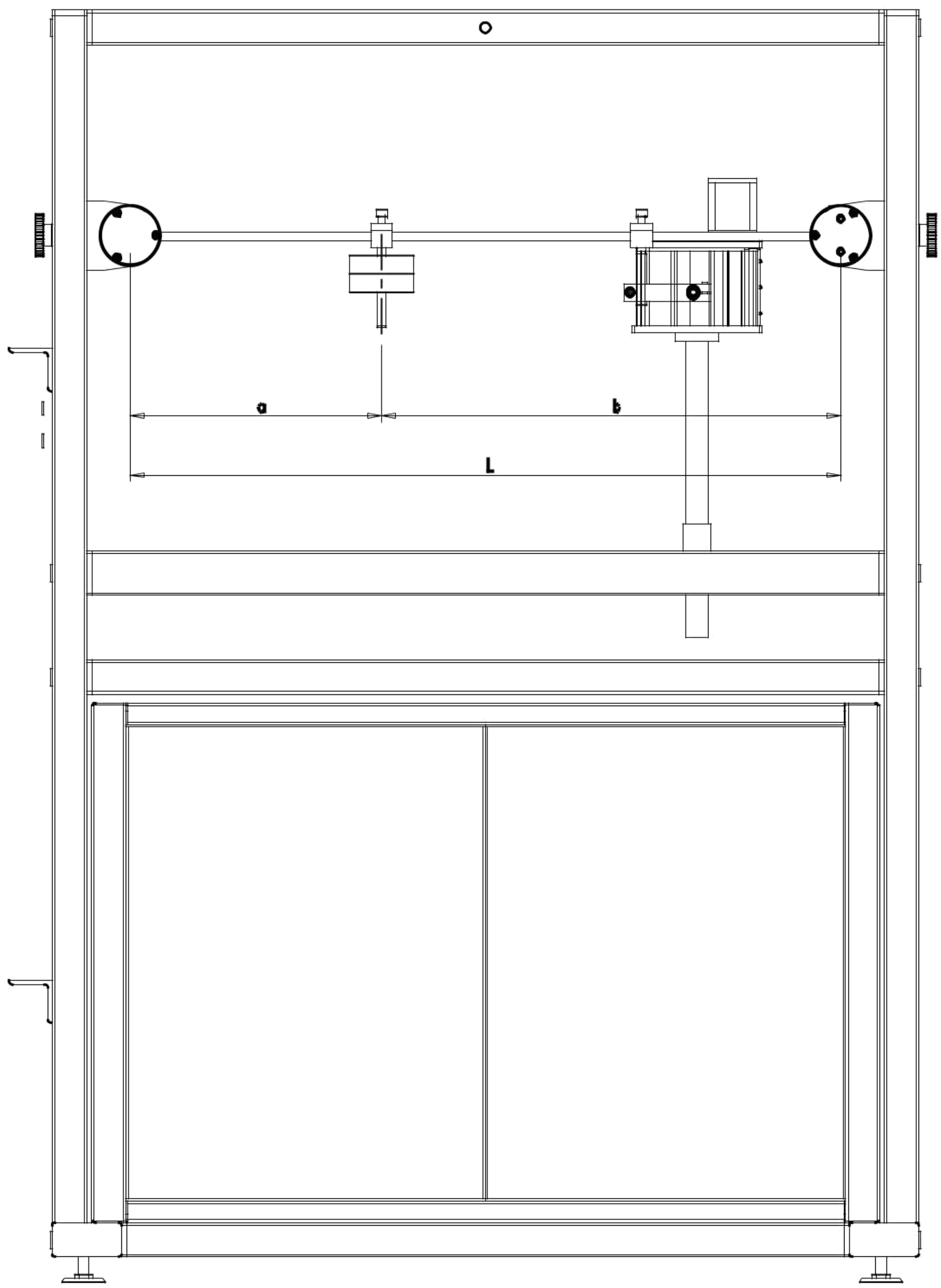

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		VB00-0000 -

ALL DIMENSIONS ARE IN MM

Sample Calculations

Sr. No.	Length of beam, m	Weight w_1	Weight w_2	a_1	a_2	Time for 10 Oscillations
1	0.830	1.79	-	0.400	-	1

CALCULATIONS

t_{expt}. = time for 10 oscillations/10 =
0.10 f_n = 1/0.1 = 10

Theoretically, by Dunkerley's equation

$1/f_n^2 = 1/f^2 n_1 + 1/f^2 n_s$

Where,
f_n = frequency of transverse vibration of system = 1/ t
f_{n1}, f_{n2} = frequency of vibrations with m_1, m_2 weights,
f_{ns} = frequency of transverse of vibrations beam under its own weight

Now Transverse vibration for simply supported beam
$f_{n1} = 0.4987 / \sqrt{\delta_1}$ (when is in m)

where,
δ_1 = Deflection due to weight m_1
= $(m \cdot g \cdot a^2 \cdot b^2) / (3 \times E \times I \times L)$ m
Where,
m = 1.79 kg
a = 0.430; b = 0.500 L = 0.830 (Length of beam)
g = 9.81 m/sec^2
E = 27 x 10^5 bar = 27 x 10^5 x 10^5 N/m^2
I = (1/12) x bd^3 (b= 25 mm; d= 6 mm)
= 4.5 x 10^{-10} m^4

Therefore putting all values
$\sqrt{\delta_1} = \sqrt{(1.79 \times 9.81 \times 0.43^2 \times 0.50^2) / (3 \text{ X } 27 \text{ X } 4.5 \text{ X } .830)}$

= 0.00171

Therefore

$f_{n1} = 0.4987 / \sqrt{\delta_1} = 12.034$

Similarly

$f_{ns} = 0.5987 / \sqrt{\delta s}$

where δs = deflection due to weight of beam, = $(5 \times w \times L^4) / (384 \times E.I)$

Where,

w = Uniformly distributed load (thin beam weight) = 11.45 N/m

$\sqrt{\delta s} = \sqrt{\{(5 \times 10.755 \times 0.830^4) / (384 \times 27 \times 4.5)\}} = 0.000462$

$f_{ns} = 0.5987 / \sqrt{\delta s} = 88.003$

Now

$1/f^2 n_1 + 1/f^2 n_s = 0.00690 + 0.00012912 = 0.007033499$

fn (theo) = 12.03

CONCLUSION

Hence Dunkerly thereom is proved

Reference video link:

https://www.youtube.com/watch?v=qK9Fayqm6XI
https://www.youtube.com/watch?v=AA6gWHu7GRs
https://www.youtube.com/watch?v=ydfIDCPUgYo

UNIVERSAL VIBRATION APPARATUS

EXP-13 FORCED DAMPED VIBRATIONS OF SIMPLY SUPPORTED BEAM

AIM- To study the forced damped vibrations of Simply supported beam

PROCEDURE-

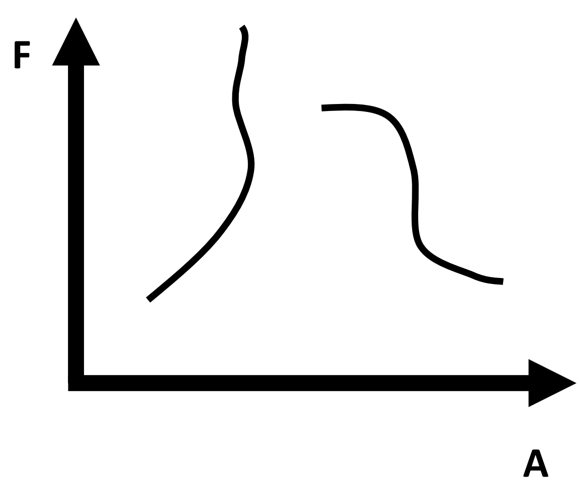
Attach the thicker beam between the truinon bracket. Fix the exciter over the beam at the center position. Attach the damper to the system. Set the damper at required damping. Fix the vibration recorder. Start the exciter and set the speeds. Start vibration recorder. Record vibration at different speeds. At resonance speed, the amplitude of vibrations may be large and disturbed. Hold the beam by hand if amplitude is too large and cross the resonance speed. Note the vibration both above and below the resonance speed.

Repeat the procedure by changing the damping.

Sr. No.	Frequency	Amplitude

Note:- Speed of paper roller is 610 mm / 10 sec (or 610 mm over the paper roll corresponds to 10 sec)

Plot the graph of Amplitude v/s Frequency at various damping



Reference video link:

https://www.youtube.com/watch?v=swJULZs71Oo
https://www.youtube.com/watch?v=k2h8YainuC8
https://www.youtube.com/watch?v=s4T_TDB0UpQ

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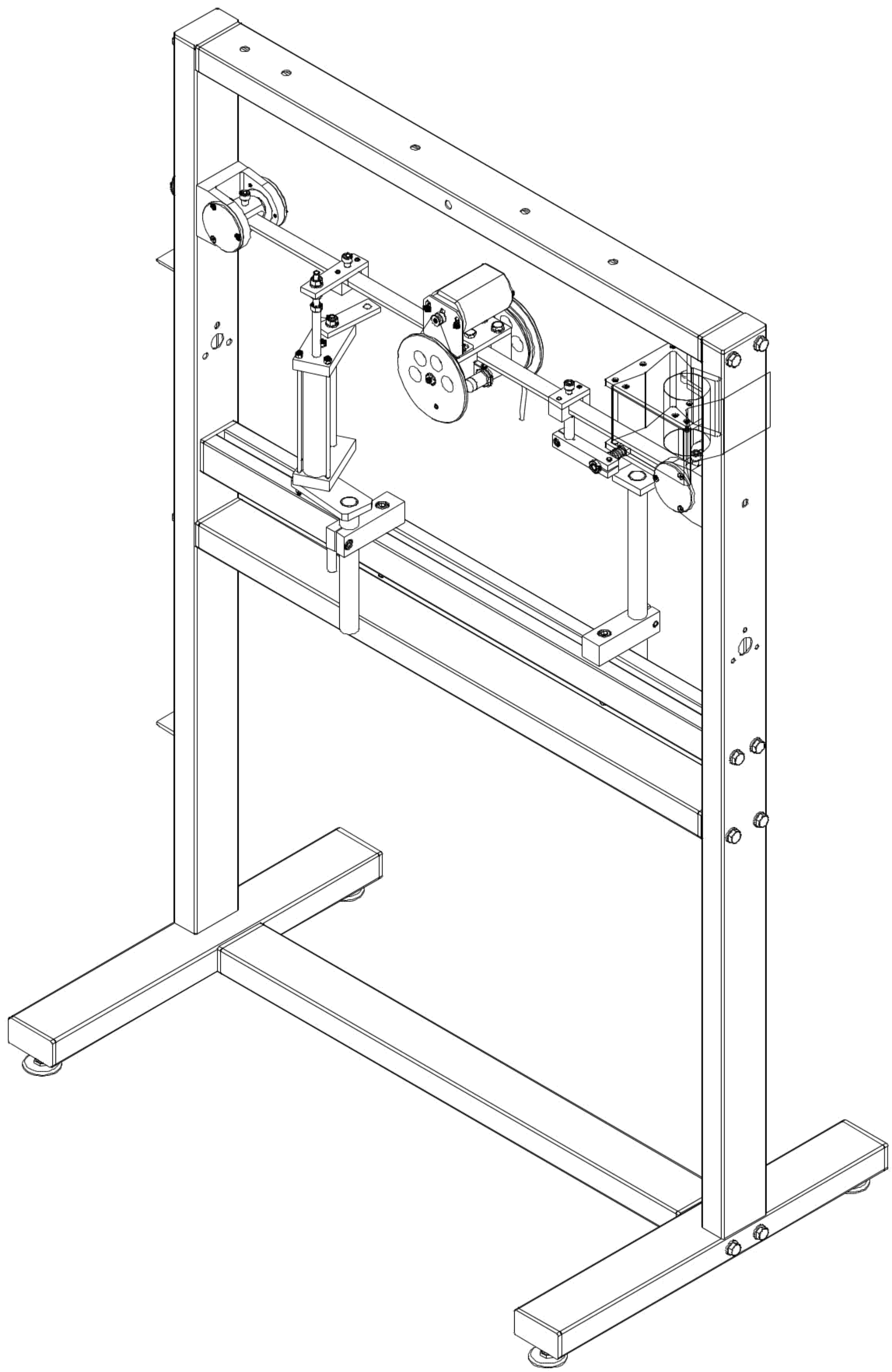

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