Experiment No. : 2

Title of Experiment : Verification of Law of Moments using Bell Crank Lever

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Semester : 1

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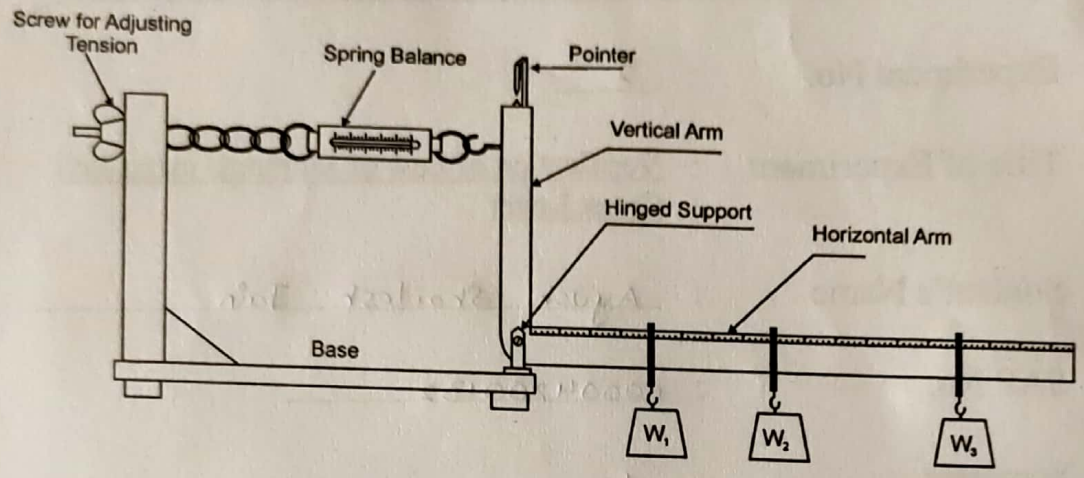
Punctuality	Reading & Understanding	Application	Total	Signature & Date
02	04	04	10	

DJ19FEC104.01	*Illustrate the effect of force and moment and apply the same along with the concept of equilibrium systems with the help of FBD.*
DJ19FEC104.02	*Demonstrate the understanding of Centroid and its significance and locate the same.*
DJ19FEC104.03	*Correlate real life application to specific type of friction and estimate required force to overcome friction.*
DJ19FEC104.04	*Establish relation between velocity and acceleration of a particle and analyze the motion by plotting the relation.*
DJ19FEC104.05	*Analyze general plane motion of rigid bodies using Instantaneous centre.*
DJ19FEC104.06	*Analyze particles in motion using force and acceleration, work-energy and impulse-momentum principles.*

Set-up Diagram



BELL CRANK LEVER APPARATUS

Experiment No: 2 **Date:** 18/03/2021

Title : **Verification of Law of Moments using Bell Crank Lever**

Aim: To verify the Principle of Moments using the Bell Crank Lever apparatus.

Apparatus :

Bell crank lever apparatus, hangers, weights, scale.

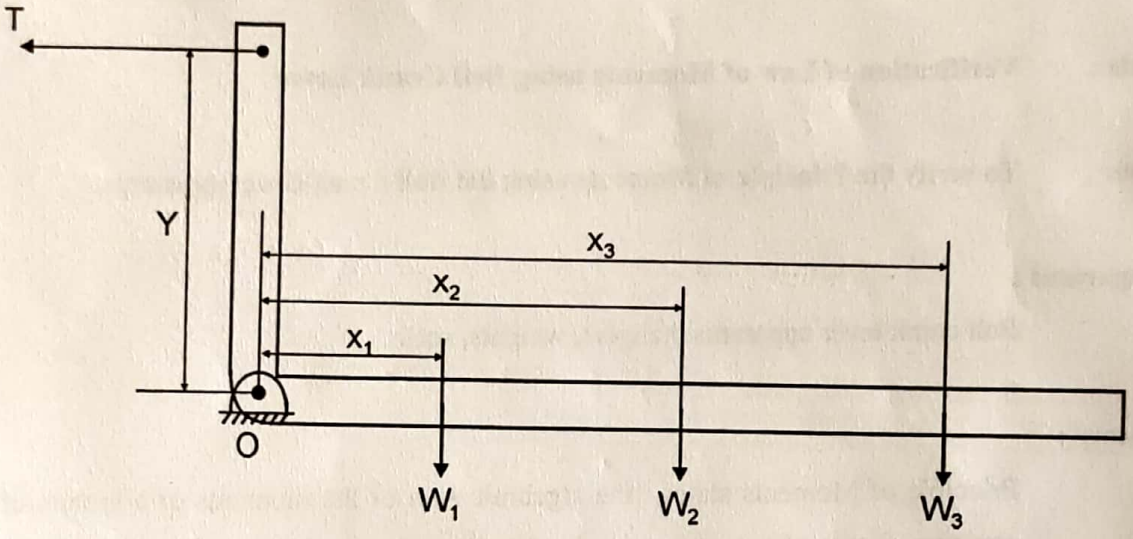
Theory :

Principle of Moments states, 'the algebraic sum of the moments of a system of coplanar forces about any point in the plane is equal to the moment of the resultant force of the system about the same point'.

This principle would be verified for a bell crank lever arrangement.

A lever whose two arms form a right angle, or nearly a right angle and having its fulcrum at the apex of the angle is referred to as a bell crank lever. These levers were originally used to operate the bell from a long distance especially where change in direction of bell wires was involved and hence the name. Now bell crank levers are used in machines to convert the direction of reciprocation movement.

Free Body Diagram



Observation Table:

Sr. No.	T_i (N)	Y (m)	W_1 (N)	W_2 (N)	W_3 (N)	X_1 (m)	X_2 (m)	X_3 (m)	T_f (N)	$T = T_f - T_i$ (N)	ΣM (Nm)
1	10	0.205	4.54	2.5	4	0.2	0.3	0.45	25.7	15.7	-0.24
2	0	0.205	4.96	3.36	2.93	0.2	0.4	0.6	21	21	0.211
3	0	0.205	4.96	2.86	3.36	0.25	0.35	0.45	20	20	0.347

Procedure:

1. Arrange three hangers at arbitrary locations on the horizontal arm. Note the locations X_1 , X_2, and X_3 of these hangers from the hinge. Adjust the tension in the spring connected to the vertical arm such that the two pointers come in the same vertical line. In this position the horizontal arm is truly horizontal. Note the tensile force in the spring as the initial tension T_i . Also note the location Y of the spring from the hinge.
2. Hang the weights W_1, W_2 and W_3 from the hangers. This will cause the arms to tilt and the pointers to move away from each other. Now adjust the tension in the spring such that the pointers once again come in the same vertical line. The horizontal arm is once again in its horizontal position. Note the tensile force in the spring as the final tension T_f. The tensile force T on the vertical arm is the difference $T_f - T_i$.
3. Since the external forces are being supported by the single hinge at the apex of the arms, implies that the resultant of these external applied forces passes through the supporting hinge. Therefore to verify the principle of moments we need to take moments ($\sum M$) of all the external forces (which includes the weights of the hangers hanging from the horizontal arm and the tension in the spring connected to the vertical arm) about the hinge and if the total sum is zero, verifies the law of moments since the moment of the resultant is also zero at the hinge.
4. Repeat the above steps by changing the weights and their location on the horizontal arm for two more set of observations.

Calculations:

Summation moments of all external forces at the hinge O.

$\Sigma M_O = T \times Y - W_1 \times x_1 - W_2 \times x_2 - W_3 \times x_3$ (Considering the third set of readings)

$\Sigma M_O = 20 \times 0.205 - (4.96 \times 0.25) - (3.36 \times 0.45) - (2.86 \times 035)$

$= 0.347$ Nm

Result:

The sum of moments of all the applied external forces on the bell crank lever, within limits of experimental error being close to zero, is in accordance to the Principle of Moments.

Hence the experiment is verified.

Precautions:

1. Do not overload the horizontal arm as it may bend or crack at the hinge.
2. Note if any, the zero error of the spring balance and accordingly correct the readings of the tensile force.
3. Carefully place the loads in the hangers as they may slip and cause accident.