PHYSICS LABORATORY MANUAL
I B.Sc., I SEMESTER

DEPARTMENT OF PHYSICS
GOVERNMENT FIRST GRADE COLLEGE
THIRTHAHALLI
LIST OF EXPERIMENTS

1. Bar Pendulum (T v/s h graph)
2. Bar Pendulum (hT^2 v/s h^2 graph)
3. Spiral Spring
4. Static Torsion
5. Young’s Modulus by Stretching
6. Theorems on Moment of Inertia
7. Fly Wheel
8. Stefan - Boltzmann Law
Expt. Name: **BAR PENDULUM (T v/s h graph)**

**AIM:** To determine acceleration due to gravity (g) and radius of gyration (k) using bar pendulum by T v/s h graph.

**APPARATUS:** Bar pendulum, knife edge, stop clock.

**PROCEDURE:** Bar pendulum is placed horizontally on the experimental table on a knife edge, so that it is balanced at a point on the knife edge. This point on the bar pendulum is the center of gravity and is marked using a meter scale. The distance (h) for different holes from the centre of gravity is measured on one side.

The knife edge is fixed to the first hole on the bar pendulum. It is then suspended vertically for support fixed on the wall. The pencil line is marked just behind the bar pendulum at its mean position. The bar pendulum is given oscillation of small amplitude. Using a stop clock, time for 20 oscillations is calculated.

Experiment is repeated for each hole on A side and B side respectively. Observations are tabulated. A graph of T v/s h is plotted. The curve obtained is as shown in the figure. The radius of gyration (K) is determined.

**RESULT:**

1. Acceleration due to gravity, \( g = \) ______ m/sec\(^2\).
2. Radius of gyration, \( K = \) _______ m.
OBSERVATIONS:

FORMULA USED:

(1) Acceleration due to gravity, \( g = \frac{4\pi^2L}{T^2} \) in \( \text{m/sec}^2 \)

Where, \( L = \) length of equivalent simple pendulum = \( \frac{PR+QS}{2} \) in m

\( T = \) period of oscillation corresponding to the line AB in the graph.

(2) Radius of gyration, \( K = \frac{AB}{2} \) in m

EXPERIMENTAL SET UP:

NATURE OF GRAPH:
(1) **TABULAR COLUMN:** For A end:

<table>
<thead>
<tr>
<th>Hole no.</th>
<th>Distance from C.G. in m</th>
<th>Time for 20 oscillations in seconds</th>
<th>Period $T = \frac{t}{20}$ in sec</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>$t_1$</td>
<td>$t_2$</td>
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<td>1</td>
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<td>9</td>
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</tr>
</tbody>
</table>

(2) **TABULAR COLUMN:** For B end:

<table>
<thead>
<tr>
<th>Hole no.</th>
<th>Distance from C.G. in m</th>
<th>Time for 20 oscillations in seconds</th>
<th>Period $T = \frac{t}{20}$ in sec</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>$t_1$</td>
<td>$t_2$</td>
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<tr>
<td>1</td>
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</tbody>
</table>

**CALCULATIONS:**
Expt. Name: **BAR PENDULUM (hT^2 v/s h^2 graph)**

**AIM:** To determine the acceleration due to gravity (g) and radius of gyration (K) using bar pendulum by hT^2 v/s h^2 graph.

**APPARATUS:** Bar pendulum, knife edge, stop clock, etc.

**PROCEDURE:** Bar pendulum is placed horizontally on the experimental table on a knife edge, so that it is balanced at a point on the knife edge. This point on the bar pendulum is the center of gravity and is marked using a meter scale. The distance (h) for different holes from the centre of gravity is measured on one side.

The knife edge is fixed to the first hole on the bar pendulum. It is then suspended vertically from a support fixed on the wall. The pencil line is marked just behind the bar pendulum at its mean position. The bar pendulum is given oscillation of small amplitude. Using a stop clock, time for 20 oscillations is calculated.

Experiment is repeated for each hole on A side and B side respectively. Observations are tabulated as shown. A graph of hT^2 v/s h^2 is plotted. From the graph, acceleration due to gravity (g) and radius of gyrations (K) are calculated.

**RESULT:**

(1) Acceleration due to gravity, \(g = \) ______ m/sec^2.

(2) Radius of gyration, \(K = \) _______ m.
OBSERVATIONS:

FORMULA USED:

(1) Acceleration due to gravity, \( g = \frac{4\pi^2}{\text{slope of } hT^2 \text{ v/s } h^2 \text{ graph}} \) m/sec\(^2\).

(2) Radius of gyration, \( K = \sqrt{OP} \) in m

Where, OP = the x-intercept of the curve.

EXPERIMENTAL SET UP:

NATURE OF GRAPH:
**TABULAR COLUMN:**

<table>
<thead>
<tr>
<th>Hole no.</th>
<th>Distance from C.G. in m</th>
<th>Time for 20 oscillations in seconds</th>
<th>Period $T = \frac{t}{20}$ in sec</th>
<th>$hT^2$ in m/sec$^2$</th>
<th>$h^2$ in m</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td>$t_1$</td>
<td>$t_2$</td>
<td>$t = \frac{t_1 + t_2}{2}$</td>
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</tbody>
</table>

**CALCULATIONS:**
**Expt. Name:** SPIRAL SPRING

**AIM:** To determine the force constant and acceleration due to gravity using spiral spring.

**APPARATUS:** Spiral spring, hanger, slotted weights, stop clock, meter scale, stand, etc.

**PROCEDURE:** Hang a spiral spring from a rigid support as shown in figure and attached a scale pan. With no load in the scale-pan, note down the zero reading of the pointer on the scale. Place gently in the pan a load of, say 50 gm. Now the spring slightly stretches and the pointer moves down on the scale. In the steady position, note down the reading of the pointer. The difference of the two readings is the extension of the spring for the load in the pan. Increase the load in the pan in equal steps until maximum permissible load is reached and note down the corresponding pointer readings on the scale. The experiment is repeated with decreasing loads.

A graph of extension v/s load is plotted. The slope of straight line is found. Then force constant i.e., force per unit extension is calculated using the formula

\[ K = \frac{1}{\text{slope}}. \]

Load the pan. Displace the pan vertically downward through a small distance and release it. The spring performs simple harmonic oscillations. With the help of a stop watch, note down the time of a number of oscillation (say 20 or 30). Now divide the total time by the number of oscillations to find the time period (time for one oscillation) \( T_1 \). Increase the load in the pan to \( M_2 \). As described above, find the time period \( T_2 \) for this load. Repeat the experiment with different values of load.

Then acceleration due to gravity is calculated using the formula,

\[ g = \frac{4\pi^2(m_2 - m_1)\text{slope}}{K(T_2^2 - T_1^2)} \text{m/sec}^2 \]

**RESULT:**

(1) Force constant, \( K = \) ________ kg/m.

(2) Acceleration due to gravity, \( g = \) ________ m/sec\(^2\).
OBSERVATIONS:

FORMULA USED:

(1) Force constant \( K = \frac{1}{\text{slope of extension versus load}} \) in kgm\(^{-1}\)

(2) Acceleration due to gravity, \( g = \frac{4\pi^2 (m_2 - m_1) \times \text{slope}}{T_2^2 - T_1^2} \) in m/sec\(^2\)

Where, \( m \) = total mass applied to spring in kg.

\( T \) = time period of oscillation in sec.

EXPERIMENTAL SET UP:

![Diagram of experimental setup]

H = Hanger
W = dead load
M = Mass in kg
S = Spiral Spring
R = Rigid support
C = Centimeter scale
P = Pointer

NATURE OF GRAPH:

![Graph diagram]

\( \text{slope} = \frac{AB}{BC} \)
(1) **TABULAR COLUMN:** To find the force constant $K$:

<table>
<thead>
<tr>
<th>Load in kg</th>
<th>Pointer reading in cm</th>
<th>Extension $(x-x_0)$ in m</th>
</tr>
</thead>
<tbody>
<tr>
<td>Load increasing $x_1$</td>
<td>Load decreasing $x_2$</td>
<td>Mean $x = \frac{x_1 + x_2}{2}$</td>
</tr>
</tbody>
</table>

![Table](image)

(2) **TABULAR COLUMN:** To find acceleration due to gravity $g$:

<table>
<thead>
<tr>
<th>Load in kg</th>
<th>Time for 20 oscillations in seconds</th>
<th>Mean $t = \frac{t_1 + t_2}{2}$</th>
<th>Period $T = \frac{t}{20}$ in sec</th>
<th>$T^2$ in sec</th>
</tr>
</thead>
<tbody>
<tr>
<td>$t_1$</td>
<td>$t_2$</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$m_1 =$</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$m_2 =$</td>
<td></td>
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</tr>
</tbody>
</table>

![Table](image)

**CALCULATIONS:**
Expt. Name: **STATIC TORSION**

**AIM:** To determine the rigidity modulus $\eta$ of the material of given rod by static torsion.

**APPARATUS:** Static torsion apparatus, weight hanger, screw gauge.

**PROCEDURE:** In static torsion apparatus, one end of the experimental rod is fixed firmly, the other end is fixed to a circular pulley. The free end of cord is attached to a weight hanger. The twist between two points separated by a distance ‘$l$’ can be measured by circular scale.

First, rod is brought into cyclic state. For this, the cord is round over the pulley in clock wise direction. Weights are added to the hanger in steps of 0.5kg till maximum convenient load is reached. The load is decreased in similar steps.

The cord is now round in anti-clockwise direction and the experiment is repeated. In each case pointer reading is noted.

Experiment is repeated by decreasing the load. From the observations, twist ‘$\phi$’ for load ‘$m$’ is calculated by the method of differences.

The length of the load ‘$l$’ from the fixed point to the pointer is measured. Using a screw gauge, the diameter of the rod is measured and radius ‘$r$’ is calculated. The radius ‘$R$’ of the pulley is determined by finding its circumference using a thread.

A graph of load v/s twist is plotted. The slope of straight line is found. Using the formula rigidity modulus is calculated.

**RESULT:** Rigidity modulus of the material of the rod, $\eta = \underline{\text{________}} \text{ N/m}^2$. 
OBSERVATIONS:

FORMULA USED: Rigidity modulus of the material of the road,

\[ \eta = \frac{360^0 gRL}{\pi^2 r^4} \times \text{slope of load v/s twist in N/m}^2 \]

Where, \( g = \text{acceleration due to gravity in m/sec}^2 \).

\( R = \text{radius of pulley in m.} \)

\( L = \text{Distance between fixed end and the pointer = ________ m.} \)

\( r = \text{radius of the rod in m.} \)

EXPERIMENTAL SET UP:

Nature of Graph:

To find Radius of pulley:

Circumference of the pulley, \( C = \text{______ cm.} \)

We know that, \( C = 2\pi R \) and \( R = \frac{2\pi}{C} = \text{______} = \text{__________ m} \)
Table-1: To find the radius of the rod using screw gauge:

Pitch of screw gauge, \( P = \frac{\text{distance moved}}{\text{no. of rotations given}} = \) ________

L.C. of screw gauge, \( LC = \frac{\text{Pitch}}{\text{HSD}} = \) ________ mm.

Zero error with sign, \( ZE = \) ___

TABULAR COLUMN:

<table>
<thead>
<tr>
<th>Trial no.</th>
<th>PSR in mm</th>
<th>HSR in division</th>
<th>TR=PSR+(HSR-Z)LC in mm</th>
<th>Mean d in mm</th>
</tr>
</thead>
<tbody>
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</tr>
</tbody>
</table>

Mean radius, \( d = \frac{r}{2} = \) __________m.

Table-2: To find the twist \( \phi \):

TABULAR COLUMN:

<table>
<thead>
<tr>
<th>Trial no.</th>
<th>Load in kg</th>
<th>Pointer reading in cm</th>
<th>Mean twist ( \theta = \frac{\phi_1 + \phi_2}{2} ) in m</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Clock wise</td>
<td>Anti-clock wise</td>
</tr>
<tr>
<td>( \theta_1 )</td>
<td>( \theta_2 )</td>
<td>( \phi_1 )</td>
<td>( \theta_1 )</td>
</tr>
<tr>
<td></td>
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</tr>
</tbody>
</table>

CALCULATIONS:
Expt. Name: **YOUNG’S MODULUS BY STRETCHING**

**AIM:** To determine young’s modulus (q) of the material of the thin wire by stretching.

**APPARATUS:** scale and screw gauge, stretching apparatus, weight hanger, etc.

**PROCEDURE:** Using a screw gauge, the diameter of the experimental wire is measured for 3 trails and its average radius ‘r’ is calculated.

The experimental wire is brought into cyclic shape by loading it in equal steps of 0.5kg up to a maximum by 2.5kg and unloaded in equal steps. This is repeated to 3 to 4 times. The reading on the screw scale is noted.

Weights are added to the hanger in equal steps by 0.5kg to a maximum of 2.5kg and in each case readings are noted. The load is then decreased in similar steps and in each step the reading is noted.

In each observation, the average screw reading for each load is calculated. The extension (l) of the wire for mass (m) is determined by the method of differences.

A graph of load versus extension is plotted. The slope of the straight line is measured.

The young’s modulus of the wire is calculated using the equation,

\[ q = \frac{gl}{\pi r^2} \times \text{slope in Nm}^{-2} \]

**RESULT:** Young’s modulus of material of wire, \( \eta = \text{_________Nm}^2 \).
OBSERVATIONS:

FORMULA USED: Young’s modulus of the material of the thin wire,

\[ q = \frac{gL}{\pi r^2} \times \text{slope of load vs extension in N/m}^2 \]

Where, \( g \) = acceleration due to gravity in m/sec\(^2\).

\( L \) = Length of experimental wire in m.

\( r \) = radius of the experimental wire = 2m.

EXPERIMENTAL SET UP:

![Diagram of experimental set up](image)

NATURE OF GRAPH:

![Graph showing load vs extension](image)
Table-1: To find the radius of the wire using screw gauge:

Pitch of screw gauge, \( P = \frac{\text{distance moved}}{\text{no. of rotations given}} = \ldots \)

L.C. of screw gauge, \( LC = \frac{\text{Pitch}}{HSD} = \ldots \) mm.

Zero error with sign, \( ZE = \ldots \)

**TABULAR COLUMN:**

<table>
<thead>
<tr>
<th>Trial no.</th>
<th>PSR in mm</th>
<th>HSR</th>
<th>TR=PSR+(HSR-Z)LC in mm</th>
<th>Mean d in mm</th>
</tr>
</thead>
</table>

Mean radius, \( d = \frac{r}{2} = \ldots \) m.

Table-2: To find the extension of wire:

Least Count = \( \frac{\text{Pitch}}{HSD} = \ldots \) mm.

**TABULAR COLUMN:**

<table>
<thead>
<tr>
<th>Load in kg</th>
<th>Reading in mm</th>
<th>Extension ((x-x_0)) in m</th>
</tr>
</thead>
<tbody>
<tr>
<td>Load increasing ( x_1 )</td>
<td>Load decreasing ( x_2 )</td>
<td>Mean ( x = \frac{x_1 + x_2}{2} )</td>
</tr>
<tr>
<td>( x_0 = \ldots )</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**CALCULATIONS**
Expt. Name: **THEOREMS ON MOMENT OF INERTIA**

**AIM:** To verify the theorem of parallel axis for moment of inertia and to determine rigidity modulus of suspension wire.

**APPARATUS:** Given wire with check nuts, two equal masses, a rectangular metallic scale, stop clock etc.

**PROCEDURE:** The given wire is fixed at the center of a rectangular metallic scale with the help of check nuts. It is freely suspended from a fixed end using a wire. The center of scale is made heavy by putting heavy mass. Two inertial weights say mass 100 grams are kept on the scale at equal distance x from the x-axis on either side.

The scale is set into horizontal oscillations of small amplitude using an index, time for 20 oscillations are noted. The period of oscillation T is calculated. Experiment is repeated for four different positions in steps.

A graph of $T^2$ versus $x^2$ is plotted. The slope of the straight line obtained is measured. According to parallel axis theorem, $Tx^2$ is proportional to $Tt^2$, $Mx^2$. Therefore $T^2$ versus $x^2$ graph must be straight line. This is the verification of parallel axis theorem.

**RESULT:** Rigidity modulus of material of wire, $\eta = \underline{\text{_______}} \text{ Nm}^{-2}$.
**OBSERVATIONS:**

**FORMULA USED:** Rigidity modulus of the material of the wire,

\[ \eta = \frac{16\pi M l}{r^4} \times \frac{1}{\text{slope of } T^2 \text{ v/s } x^2 \text{ graph}} \text{ in N/m}^2 \]

Where, \( M \) = Mass placed on either side of metal scale in kg.

\[ l = \text{length of the wire} = \underline{\text{______}} \text{ m.} \]

\[ r = \text{radius of the wire in m.} \]

**EXPERIMENTAL SET UP:**

![Diagram of experimental setup](image)

**NATURE OF GRAPH:**

![Graph of \( T^2 \) v/s \( x^2 \)](image)
**Table-1:** To find the radius of the wire using screw gauge:

Pitch of screw gauge, \( P = \frac{\text{distance moved}}{\text{no. of rotations given}} \) = \( \ldots \) mm.

L.C. of screw gauge, \( LC = \frac{\text{Pitch}}{\text{HSD}} \) = \( \ldots \) mm.

Zero error with sign, \( ZE = \ldots \)

**TABULAR COLUMN:**

<table>
<thead>
<tr>
<th>Trial no.</th>
<th>PSR in mm</th>
<th>HSR in division</th>
<th>TR = PSR + (HSR - Z)LC in mm</th>
<th>Mean d in mm</th>
</tr>
</thead>
<tbody>
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</tbody>
</table>

Mean radius, \( d = \frac{r}{2} = \ldots \) mm.

**Table-2:** To find the time period \( T \):

<table>
<thead>
<tr>
<th>Trial no.</th>
<th>Distance ( x ) in m</th>
<th>Time for 20 oscillations in sec ( t = \frac{t_1 + t_2}{2} )</th>
<th>Period ( T = \frac{t}{20} ) in sec</th>
<th>( x^2 ) in ( m^2 )</th>
<th>( T^2 ) in sec(^2)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tbody>
</table>

**CALCULATIONS:**
Expt. Name: **FLY WHEEL**

**AIM:** To determine moment of inertia of a flywheel about its axis of rotation and hence to calculate its mass.

**APPARATUS:** Fly wheel, stop clock, weight hanger, slotted weights, etc.

**PROCEDURE:** Using a vernier calipers the average radius ‘r’ of the axle is determined. Using a thread, the circumference C of the wheel is measured. Its radius is calculated using the formula \( R = \frac{C}{2\pi} \).

A thread is fixed to the peg in the axel and is wound round the axel for a few turns without overwrapping. To the other end, a weight hanger is attached. A mark is made on the wheel and is held such that, the index coincides with the mark.

A load ‘m’ in kg is placed in the hanger without any initial jerk, the wheel is allowed to rotate. Simultaneously a stop clock is started. The time t for 10 revolutions before the load reaches the ground is noted. The experiment is repeated for 3 trials and average time for n revolutions is noted. The angular acceleration \( \alpha \) is calculated using the formula, \( \alpha = \frac{4\pi n}{t^2} \).

Experiment is repeated for different loads. Observations are tabulated as shown.

A graph of angular acceleration versus mass is plotted. The slope of the straight line is calculated. The moment of inertia of the fly wheel about the axis of rotation is calculated using the formula, \( I = g \times r \times \frac{1}{\text{slope}} \) in \( km^2 \).

The mass ‘m’ is calculated using the formula \( M = \frac{2I}{R^2} \) in kg.

**RESULT:**

1. Moment of inertia of flywheel, \( I = ______ \) kgm\(^2\).
2. Mass of flywheel, \( M = ______ \) kg.
OBSERVATIONS:

FORMULA USED:

(1) The moment of inertia of the fly wheel, \( I = g \times r \times \frac{1}{\text{slope}} \) in \( kgm^2 \)

(2) The mass of the fly wheel, \( M = \frac{2I}{R^2} \) in \( kg \)

Where, \( g = \) acceleration due to gravity in \( m/sec^2 \).

\( r = \) radius of the axel in \( m \).

\( R = \) Radius of the wheel in \( m \).

EXPERIMENTAL SET UP:

![Experimental Set Up Diagram]

NATURE OF GRAPH:

To find Radius of wheel:

Circumference of the wheel, \( C = \) ______ cm.

We know that, \( C = 2\pi R \) and \( R = \frac{2\pi}{C} = \) ______ = ______ m
Table-1: To find the radius of the axel using vernier calipers:

L.C. of vernier calipers, $LC = \frac{Pitch}{HSD} = \text{--------- cm.}$

**TABULAR COLUMN:**

<table>
<thead>
<tr>
<th>Trial no.</th>
<th>MSR in cm</th>
<th>CVD</th>
<th>TR=MSR+(CVD)LC in cm</th>
<th>Mean d in cm</th>
</tr>
</thead>
</table>

Mean radius, $d = r/2 = \text{__________ m.}$

Table-2: To find the angular acceleration:

<table>
<thead>
<tr>
<th>Trial no.</th>
<th>Mass attached to thread m in kg</th>
<th>Time for ‘n’ rotations in sec</th>
<th>$t^2$ in sec</th>
<th>$\alpha = \frac{4\pi n}{t^2}$ in rad/sec$^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>$t_1$</td>
<td>$t_2$</td>
<td>$t = \frac{t_1 + t_2}{2}$</td>
</tr>
</tbody>
</table>

**CALCULATIONS:**
Expt. Name: **STEFAN - BOLTZMANN LAW**

**AIM:** To determine the radiation index ‘n’ by using log I versus log R graph.

**APPARATUS:** Meter Bridge, Galvanometer, Resistance box, Rheostat, etc.

**PROCEDURE:** The connections are made as shown in the circuit diagram. Suitable resistance S in resistance box is kept constant. The current in the milliammeter is adjusted by using a rheostat and the corresponding balancing length ‘l’ is measured using sliding contact and also the value (1-l) is determined.

Finally calculate the resistance ‘R’ of the filament and is calculated using the formula, \( R = \frac{sl}{1-l} \) in Ω where S is the constant value of resistance.

The experiment is repeated for 3 trials. In each case the length l and R are determined. The values of log C and log R are calculated. A graph of log I vs log R is drawn. The slope of straight line is measured. Using the value of slope, we can calculate the radiation index ‘n’ by the formula \( n = (2m+1) \) where m is the slope.

**RESULT:** Radiation index, \( n = \) ________

Stefan Boltzmann law is verified.
OBSERVATIONS:

FORMULA USED:

(1) Resistance of the filament of the bulb, \( R = \frac{SL}{(1-l)} \) in Ω

(2) Radiation Index, \( n = (2m + 1) \)

Where, \( S \) = constant value of resistance in Ω.

\( l \) = balancing length in m.

\( m \) = slope of log I versus log R graph.

EXPERIMENTAL SET UP:

NATURE OF GRAPH:
**TABULAR COLUMN:**

<table>
<thead>
<tr>
<th>Trial no.</th>
<th>S in Ω</th>
<th>Current I in mA</th>
<th>Balancing length l in m</th>
<th>(1-l) in m</th>
<th>R = ( \frac{SI}{(1-l)} ) in Ω</th>
<th>log R</th>
<th>log I</th>
</tr>
</thead>
<tbody>
<tr>
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</tbody>
</table>

**CALCULATIONS:**