Miranda House
University of Delhi

INSPIRE INTERNSHIP PROGRAMME 2024

Innovation in Science Pursuits for Inspired Research
An Initiative of DST, Govt of India

8-12 JULY 2024

Sense, Measure and Control the World

Offered by:
Physics Department

Inspire Internship Programme 2024

Innovation in Science Pursuit for Inspired Research An initiative of DST Government of India

Workshop Physics: Sense, Measure and Control the World

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SPRINGS AND OSCILLATIONS

Introduction: When a body moves back and forth periodically about a mean position that motion is said to be oscillatory motion whereas when a simple harmonic system oscillates with decreasing amplitude with time is called **Damped Oscillation.**

- **Time period:** It is the least interval of time after which periodic motion of a body repeats itself.
- **Frequency:** The number of periodic motions executed by a body per second.
- **Amplitude:** The peak value of the wave motion.
- **Phase:** It is a physical quantity which completely expresses the position and direction of motion of the particle at any instant.

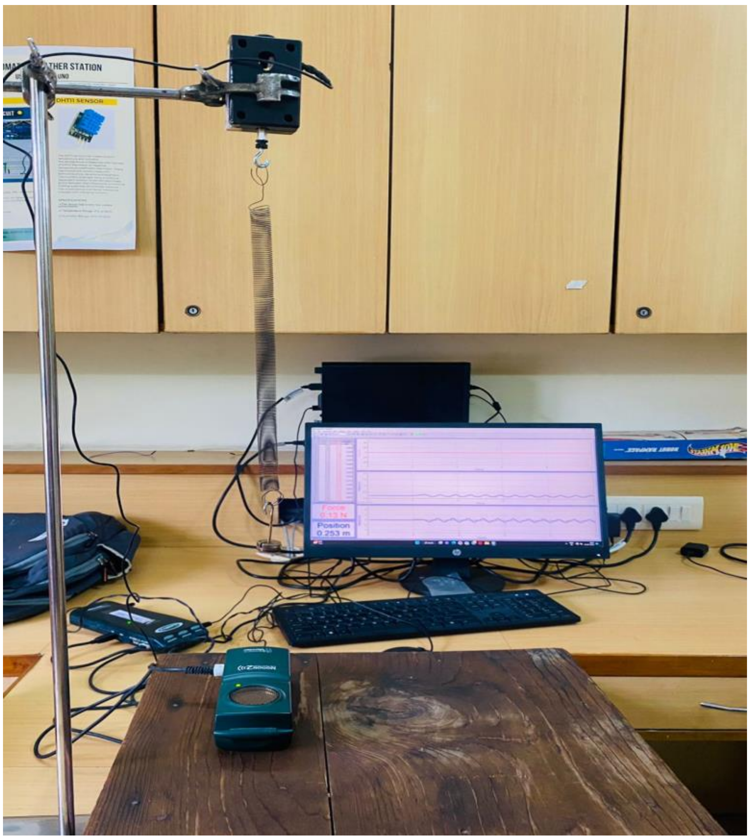
Objective: Study of simple harmonic and damped harmonic motions.

Preliminary Questions:

1. What is a restoring force?
2. What are the factors on which the restoring force depends?
3. What is Hook's law?
4. Where do we observe oscillations in our daily life?
5. Why all periodic motions are not oscillatory motions?
6. What is the time period of oscillating spring?

Apparatus Required: Computer, Labpro interface, Ultrasonic motion detector, Force sensor, Spring, masses, paper plate (for observing the damping)

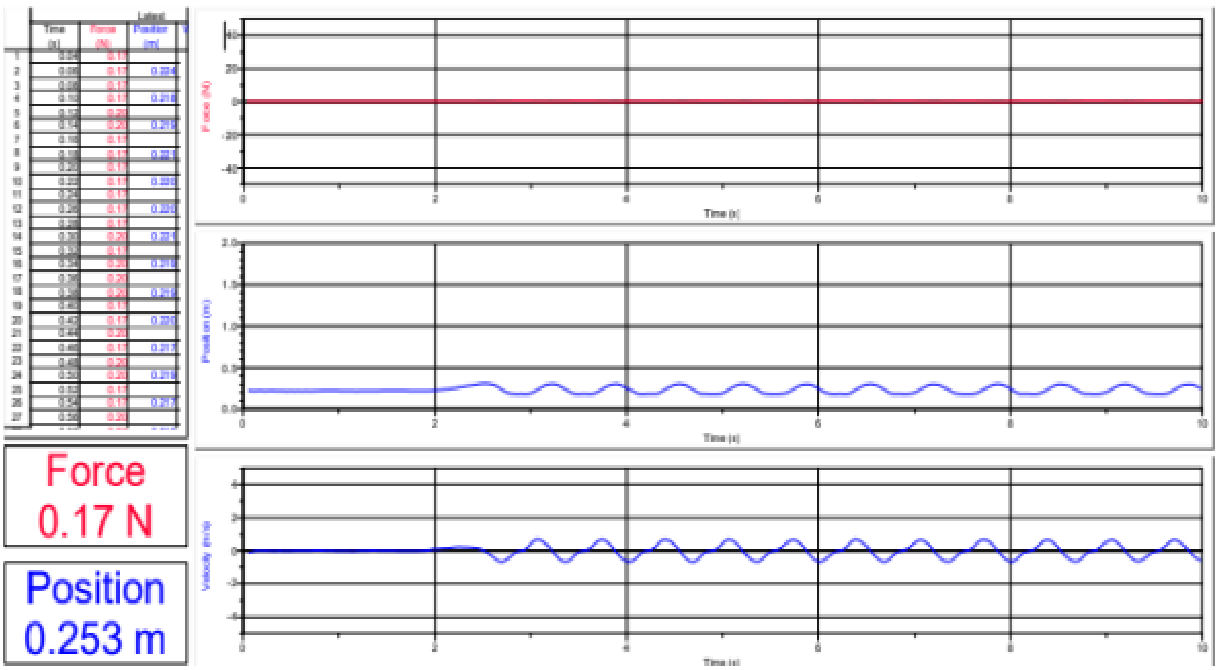
Experimental Set-up:



Experimental Procedure:

1. Attach the spring mass system to a hook in the force sensor connected to the stand.
2. Place the motion detector below the mass. The system should be adjusted so that mass is able to move 20 cm up and down and it is at least 50 cm above the motion detector.
3. Connect the motion detector to the DIG 1 of the Labpro interface.
4. Connect the force sensor to the analog CH1 of the Labpro interface.
5. Start Logger pro and select the sensors used in the present study.
6. Set the time to be 20 s and sampling rate to be 15 samples per second.
7. Put about 20 g of weight; lift the mass and release it slowly.
8. Start collecting data by clicking the *Collect (green)* button. The data collection will automatically stop after 20 sec. if you want to stop it before that, click stop (*red*) button.
9. You will get; force-time; position-time and velocity-time graphs on the screen.
10. Save data and analyze the curves.
11. Put a paper card or a cup to the bottom of the mass and repeat the measurements for 60 seconds.

Data analysis:



Post Questions:

1. Fit the position-time graph to the sinusoidal curve fit and determine the value of amplitude, frequency, time period and phase of the oscillation.
2. Draw a Force-position graph and from there find out the value of spring constant.
3. How does the restoring force vary with displacement?
4. What is motion sensor?

SENSE THE FALL

Introduction: The purpose of this experiment is to measure directly the free fall acceleration (g) due to gravity by dropping picket fence through photogate detector. This detector will be activated during fall through the clear plastic areas of picket fence and deactivated as the black areas of the picket fence pass through the detector thereby blocking the device. As the width of the black and clear areas are known and the time of fall through each type of area is being measured thus acceleration due to gravity can be computed.

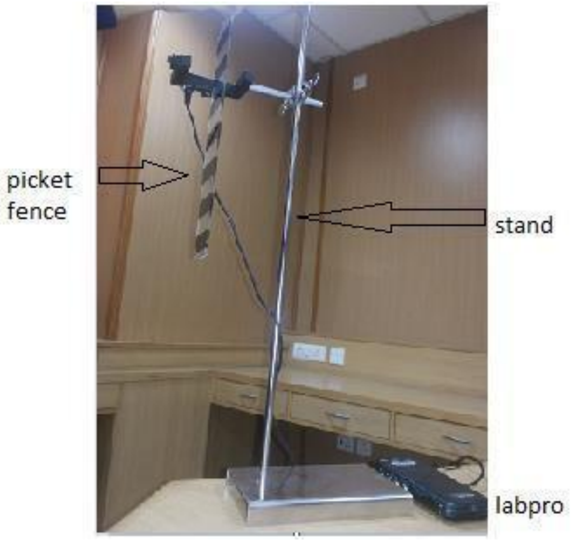
Objective: Determination of the value of acceleration due to gravity ‘g’ in a free fall.

Apparatus Required: Computer, Labpro interface, Photogate, Picket Fence, clamp and stand.

Preliminary Questions:

1. What is free fall?
2. What is picket fence?
3. Does the initial velocity of an object have anything to do with its acceleration?
4. Can the velocity of an object be zero at the same instant when its acceleration is non-zero?
5. If an object is moving with constant acceleration what is the shape of its velocity v/s time graph?
6. On what factors does acceleration due to gravity depend?

Experimental Set-up:



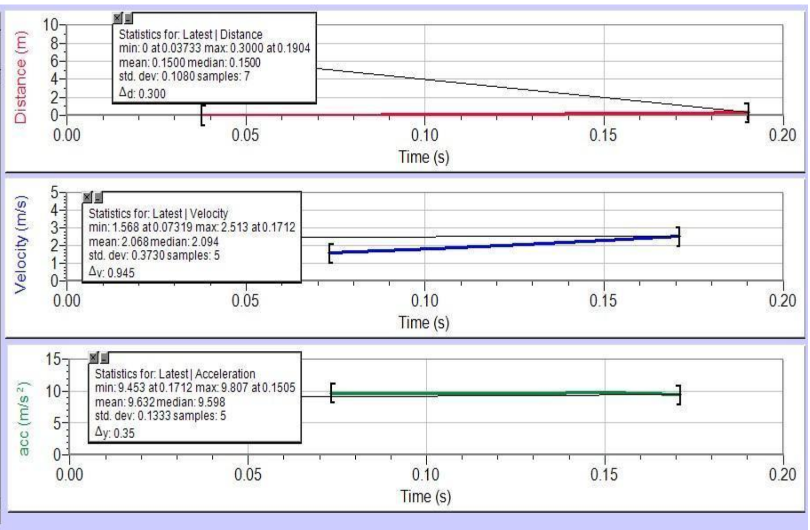
Experimental Procedure:

1. Connect the photogate to the stand as shown above in the figure.
2. Connect the photogate to the DIG 1 of the Labpro interface.
3. Start Logger pro and select the sensors used in the present study.
4. You should observe distance-time and velocity-time graphs on the screen and a table.

5. Set the time to be 10 sec and sampling rate to be 40 samples per second.
6. Start collecting data by clicking the *Collect (green)* button. The data collection will automatically stop after 10 sec. If you want to stop it before that, click stop (*red*) button.
7. Hold the top of the Picket Fence and drop it freely through the photogate, releasing it from your grasp completely before it enters the photogate. The Picket Fence must not touch the sides of the photogate as it falls and it needs to remain vertical.
8. You will get; position-time and velocity-time graphs on the screen.
9. Save data and analyze the curves.
10. To establish the reliability of your data, repeat steps 6-9 five times.

Data Analysis:

	Latest				
	Time (s)	GateState	Distance (m)	Velocity (m/s)	acc (m/s²)
1	0.037330	1	0.000		
2	0.055784	0			
3	0.073194	1	0.050	1.568	9.71
4	0.087889	0			
5	0.102430	1	0.100	1.850	9.60
6	0.115002	0			
7	0.127784	1	0.150	2.094	9.59
8	0.138893	0			
9	0.150484	1	0.200	2.314	9.81
10	0.160530	0			
11	0.171184	1	0.250	2.513	9.45
12	0.180482	0			
13	0.190384	1	0.300		
14	0.198326	0			
15					
16					
17					
18					
19					
20					
21					
22					



Post Questions:

1. What is the mechanism to "sense the fall"?
2. Measure the slope of the velocity-time graph?
3. Calculate the value of acceleration due to gravity.
4. What is a photogate?
5. Does varying width of the white and black strips on the picket fence have any impact on the acceleration due to gravity?

NEWTON'S LAWS OF MOTION

Introduction: How does a cart change its motion when you push or pull it? You might think that the harder you push on cart, the faster it goes. Is the cart velocity related to force you applied? Or Does the force just changes the velocity? Also relate the mass of a cart with the changes observed in its motion.

We know that it takes much harder punch to get a heavy cart moving than a lighter one. A force sensor and a motion sensor will help you to measure this simultaneously and thus understand the basic concepts.

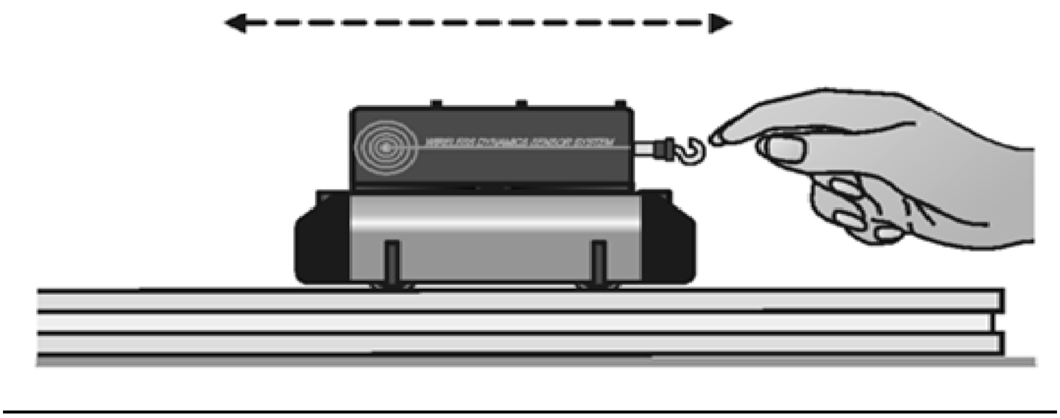
Objective: Determine the force, position and velocity of the cart as it moves back and forth. Compare the force-time and velocity –time graphs for a cart moving back and forth and hence determine the relationship between them.

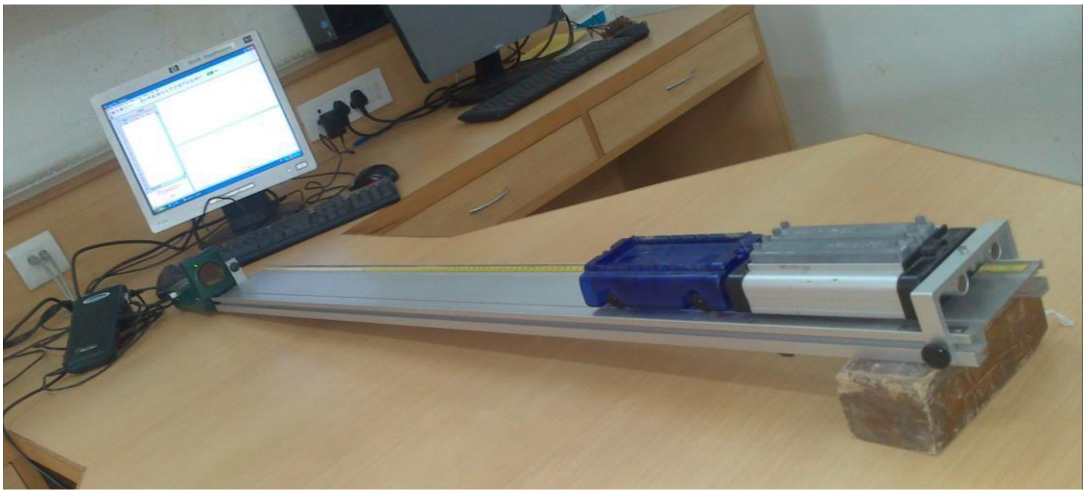
Preliminary Questions:

1. What are Newton's Laws of motion?
2. What are internal forces?
3. Are the internal forces in accordance with Newton's III Law?
4. What is impulse?
5. How would the force-time graph look like in case of an impulsive force?
6. What is the difference between an elastic and inelastic collision?
7. How does the velocity of a body on an inclined plane vary with the mass of the body?

Requirements: Computer, Labpro, force sensor, motion sensor, cart, masses, cart-track.

Experimental Set-up:



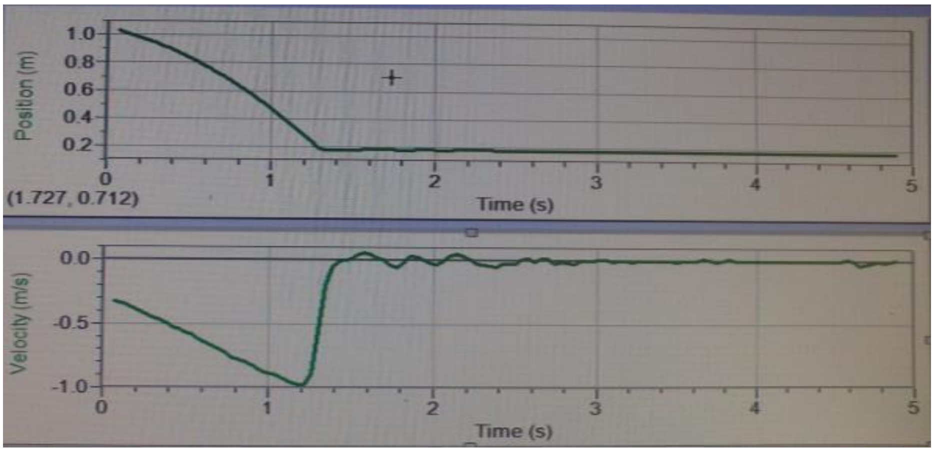


Procedure:

1. Connect the motion sensor and force sensor to the Labpro and connect it with the computer.
2. Place the cart-track on a smooth table and place the cart on the track.
3. Displace the cart with your hand, collect the data and analyze the curves.
4. Incline the track.
5. Now, leave the cart from the top of the incline, collect data and analyze the curves.
6. Repeat step 5 for different masses.
7. Now, keep 2 carts (with force sensors attached at their front) on the track and collect data of their collision and analyze the curves.
8. Attach hooks in front of the carts, pair them and pull the carts.
9. Collect data and analyze the curves.

Data Analysis:

1. Observe the graphs and identify the regions where the cart is being pushed, moving with constant velocity and colliding.
2. Compare the velocity-time graphs for different masses on the inclined plane.
3. Compare the graphs of action and reaction forces vs time.
4. What can you conclude about internal forces of a system from these graphs?
5. Compare the graphs of acceleration vs time and force vs time for a particular trial. How are they different? How are they same?
6. Is the net force on the cart proportional to its acceleration?
7. What are the units of the slope of the force vs acceleration graph?



Post Questions:

1. What other activities can you perform from this experimental set-up?
2. Is it possible to determine whether the object is accelerating or decelerating from these plots?

MOVING MAGNETS, GENERATING ENERGY

Introduction: Current is produced in a conductor when it is moved through magnetic field because the magnetic lines of force are applying force on free electrons in conductor causing them to move. This process of generating current in a conductor by placing it in changing magnetic field is called **induction.** It is called induction because there is no physical connection between the conductor and the magnet.

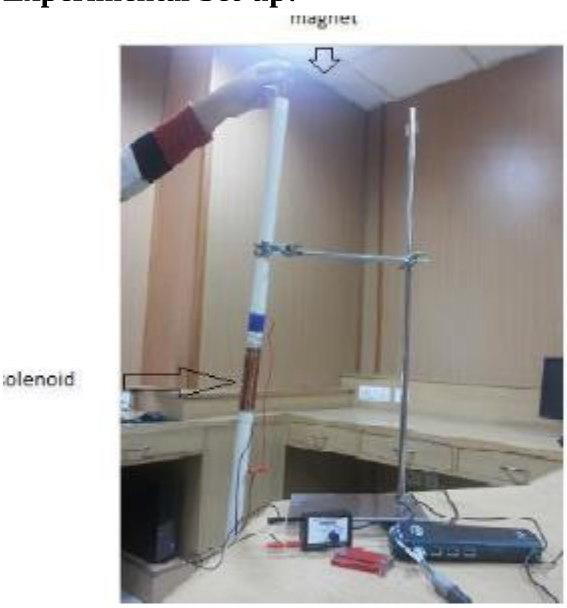
Objective: Study of induced emf due to varying magnetic field.

Preliminary Question:

1. What is induced emf?
2. What is the relation between induced emf and flux?
3. How does induced emf change in a solenoid?
4. What is the difference between a wire and a solenoid?
5. What is Faraday"s law?
6. Where do you observe phenomenon of induction?

Apparatus Required: Computer, Labpro interface, Instrumentation amplifier or a voltage sensor, solenoid, connecting wires, magnets of different strength.

Experimental Set-up:

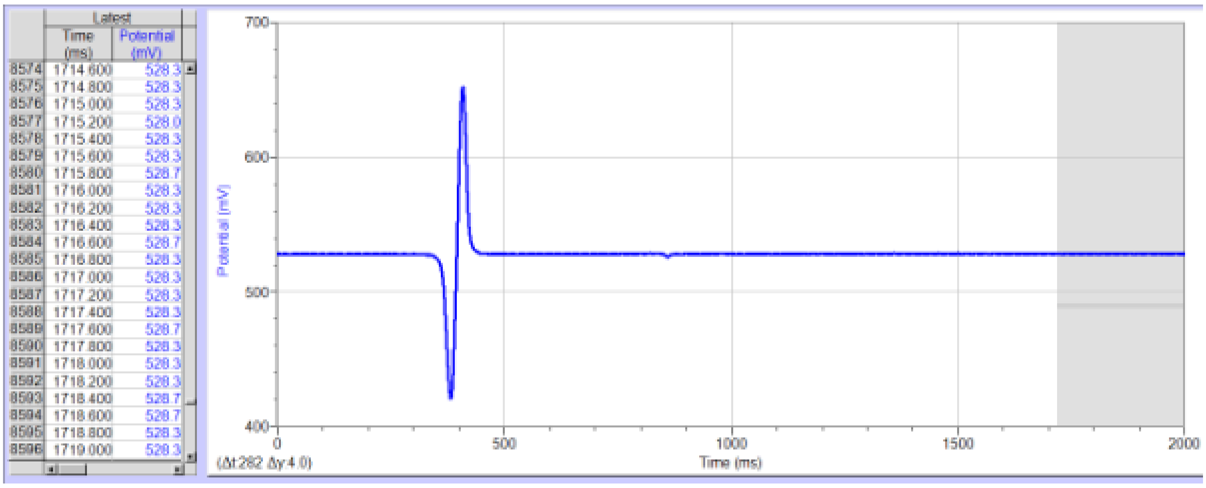


Experimental Procedure:

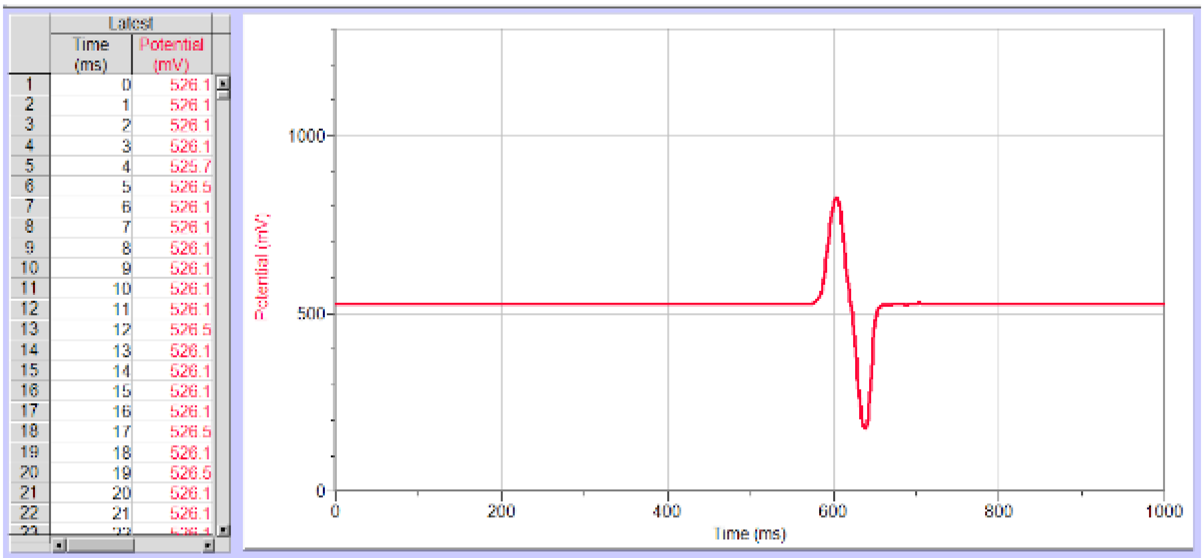
1. Connect the circuit as shown in the figure above.
2. Connect the Instrumentation amplifier to the CH1 of the Labpro interface.
3. Start Logger pro and select the sensor used in the present study.
4. Set the time of measurement to be 500 ms and sampling rate to be 1000 samples per ms.
5. You should observe Voltage-time graph on the screen and a table.
6. Click the *Collect (green)* button to record the voltage across the solenoid coil.
7. Drop the magnet when the computer is set to collect the data.

8. The data collection will automatically stop after 500 ms.
9. Save and analyze the data.

Data Analysis:



When magnet is allowed to fall from north side



When magnet is allowed to fall from south side

Post Questions:

1. Why do you observe two peaks in opposite directions?
2. How does the voltage of the second peak compared to that of the first peak?
3. Analyze the graphs obtained when you reverse the polarity of the dropping magnet
4. What if you use two bar magnets NS-NS or tape NN-SS? How will the graph look like?
5. What will be the voltage in the coil if the number of turns of the coil is increased or decreased?

LIGHT, BRIGHTNESS AND DISTANCE

Introduction: The term intensity is used to describe the rate at which light spreads over a surface of a given area some distance from the source. The intensity varies with the distance from the source and the power of the source. The intensity decreases with increasing distance from the source. Light intensity falls off according to the square of the distance between the light source and receiving device.

Objective: Study of Light irradiance measurements such as the inverse square law.
In this activity, you will use a computer to measure the intensity of transmitted light.

Preliminary Questions:

1. What is "light''?
2. What nature does light possess in a medium?
3. Why does the light intensity decrease with the increasing distance?
4. What is a monochromatic source of light?
5. Define "illumination'' and give its unit?

Apparatus Required: Computer, Labpro interface, Light sensor, light source.

Experimental Set-up:

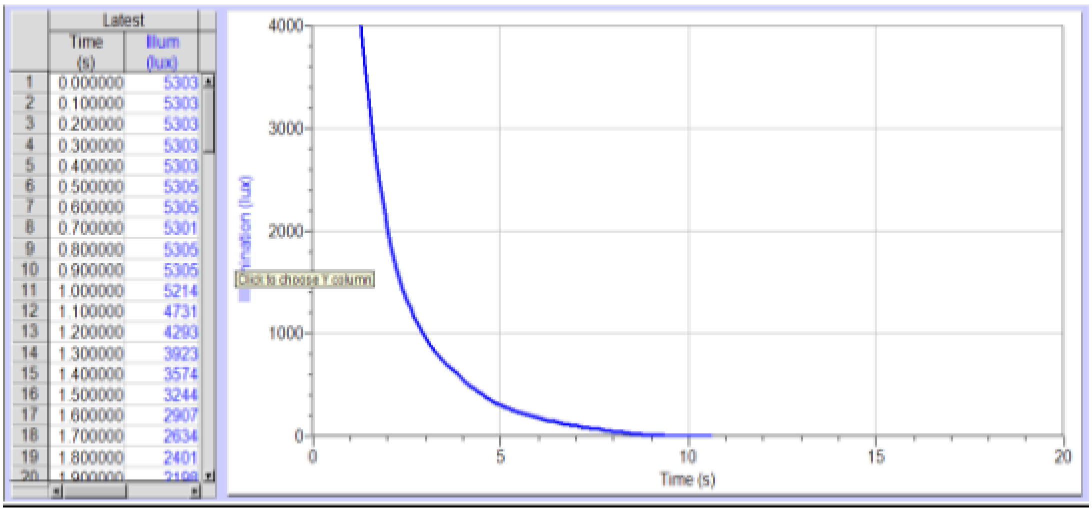
Experimental Procedure:

1. Position the light sensor on the optical bench and scale at a known distance from the light source
2. Align the height of the sensor to match the center of the light source so that the sensor is pointing directly at the light source.
3. Connect the light sensor to the analog CH1 of the Labpro interface.
4. Start Logger pro and select the sensors used in the present study.
5. Set the time to be 100 s and sampling rate to be 15 samples per second.
6. Start collecting data by clicking the *Collect (green)* button. The data collection will automatically

stop after 100 sec. If you want to stop it before that, click stop (*red*) button.

7. You will get; intensity-time; for different known distances from the source. Use data to plot intensity – distance graph on the screen.
8. Save data and analyze the curves.

Data Analysis:



Post Questions:

1. How does intensity vary with distance?
2. What does the temperature indicate?
3. Why the sky is blue, but a sunset is red? Use a flashlight, transparent rectangular container, a cup of milk and some water to find out why.

TOSS A BALL

Introduction: When a ball is tossed straight upward, the ball slows down until it reach the top of its path. The ball then speeds up on its way back. Variation of its velocity with time would throw light into its motion. In this activity, we will analyze the motion in tossing a ball and explore the trajectory of motion of a ball launched in a variety of ways.

Objective: In this activity we will collect the position, velocity, and acceleration data for a ball thrown straight up with the help of a motion detector.

Preliminary Questions

1. What is a free fall? Give some examples.
2. Where we usually observe tossing?
3. Do the velocity of a ball change with change in its mass?
4. Is there any difference in the velocity of a ball when it is going up and coming down?
5. Predict position – time graph of a ball in tossing it.
6. Is there any difference in the maximum height of a ball during consecutive bounces?
7. What forces act on the ball when it is at the maximum height and when it just touches the ground?

Requirements: Computer, LabPro with adapter, motion detector and different balls.

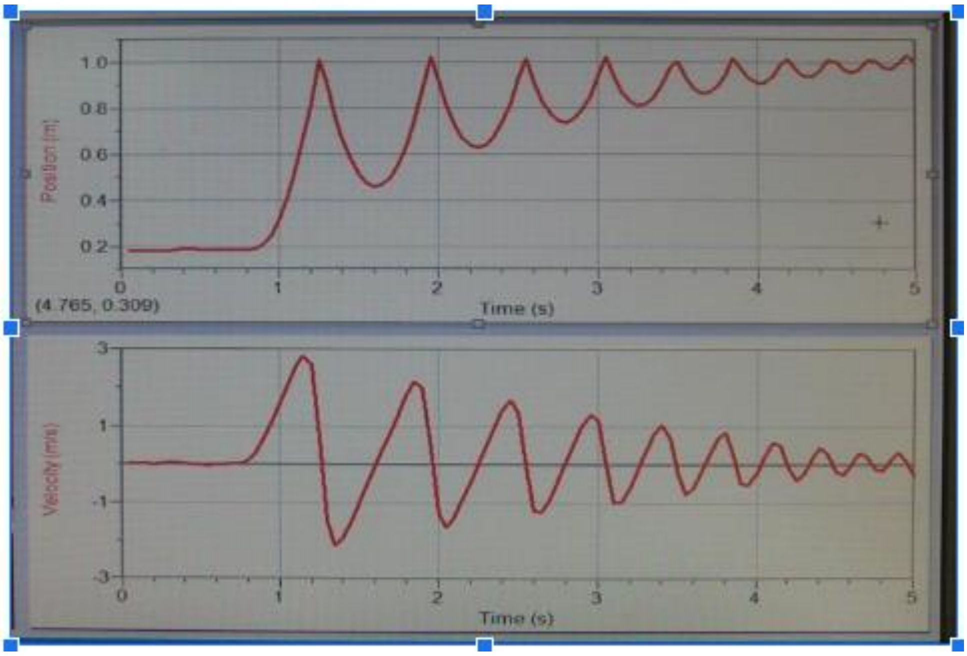
Experimental Set-up:

Procedure:

1. Connect the motion sensor to the DIG/SONIC 1 channel of the LabPro interface.
2. Hold the motion detector about one meter above the table.
3. Start logger Pro in the computer.
4. Click on collect button on the computer screen and toss the ball straight upward below the motion detector and let it fall.
5. The data collection will automatically stop after 10 seconds.
6. Graph of position-time and velocity –time will be plotted on the computer screen.
7. Save data and analyze the curve.
8. Repeat steps 4, 5, 6 and 7 with different balls.

Data Analysis:

1. Click the Examine button and move the mouse across the graphs.
   - Identify the region when the ball was being tossed but still in your hands.
   - Identify the region when the ball is in free fall.
2. On the velocity-time graph of the bouncing ball, observe the trend of the maximum velocity of the ball.
3. Also compare the slopes of the velocity-time graph at the point of bounce and the point of maximum height.
4. Compare position and velocity - time graphs for different balls.



Post Questions:

1. After observing the graphs, can you tell which ball's material is more elastic?
2. Why velocity of the ball decreases every time it touches the ground?
3. Why the ball takes longer to go up than to come down?
4. At the time, the ball touches the ground what kind of force is acting on the ball so as to change its direction?