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| **Subject:** | **Physics** | **Time: 1h 15 min** |
| **Level:** | A-Level |
| **Worksheet Title:** | **P06 – Falling Magnet through a Solenoid – Virtual Laboratory** |

**Apparatus List**

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| --- | --- |
| 01 × laptop | 01 × pre-activity worksheet |

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| 1. In this practical, electromagnetic ideas will be induced in your brains using the easy Java simulation ejs\_FallingMagnet08.jar. ☺
 |
| 1. Predict outcomes of various scenarios.
2. Explain your reasoning. (This is so that, in the unlikely event you are wrong, you can trace the wrong thinking and weed it out.)
3. Run the simulation to verify your prediction.
4. Are your predicted outcome and the simulated outcome identical? If they are not, what is the difference and what could have caused this difference? (We have to learn to check for own flaws in thinking.)
 |
| Before we start, one clarification between magnet falling down through a copper tube versus magnet falling down through a solenoid of copper wire – the induced current in the solenoid is constrained to flow along the copper wire.  |

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| **Scenario A – Setting the Baseline – Teacher go through** |
| Default Settings

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| **Parameter / unit** | **Magnitude** |
| Magnet\_Z / m | 0.500 |
| L / m (in **red** for magnet) | 0.100 |
| B / T | 2.470 |
| v / m/s (in **red** for magnet) | 0.000 |
| Solenoid\_Z / m | –0.500 |
| L / m (in **orange** for solenoid) | 0.000 **🡺 0.500** |
| 30/L  | ∞ |
| v / m/s (in **orange** for solenoid) | 0.000 |

1. **Change solenoid length to 0.500 m.**
2. **Must press Enter key. Please note that 30/L becomes 60.0 automatically.**
3. **Click on emf vs t (bottom right).**
4. **Click on Coil (bottom right above v).**
5. **Click**  **to run the simulation.**
 | *t****E*** |
| Explanation: 2nd peak higher than 1st and 2nd curve thinner than 1st curve because increase in velocity due to acceleration of free fall, hence higher rate of change of flux for magnet leaving solenoid compared to entering solenoid. Area under the two peaks are same because area under E-t graph represents change in flux linkage and it would be the same change in flux for the same magnet approaching and leaving.……………………………………………………………………………………………………………………… |
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| **Scenario B – Reversing Polarity (Will the new graph be any different from A? Why?)** |
| Default Settings

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| **Parameter / unit** | **Magnitude** |
| Magnet\_Z / m | 0.500 |
| L / m (in **red** for magnet) | 0.100 |
| B / T | 2.470 |
| v / m/s (in **red** for magnet) | 0.000 |
| Solenoid\_Z / m | –0.500 |
| L / m (in **orange** for solenoid) | 0.000 **🡺 0.500** |
| 30/L  | ∞ |
| v / m/s (in **orange** for solenoid) | 0.000 |

1. **Predict and sketch your expected *E – t* graph in blue/black.**
2. **Click Reset** **.**
3. **Change solenoid length to 0.500 m.**
4. **Press Enter key.**
5. **Reverse the polarity of the magnet so that South is down.**
6. **Press Enter key.**
7. **Click**  **to run the simulation.**
8. **Copy the simulated graph onto the same axes in red.**
 | **Predicted Graph in Blue/Black*****t******E*** |
| Explanation: Previously, N-pole approaches, so current flows clockwise such that induced effect is N. Now S-pole approaches so current flows anti-clockwise such that induced effect is S. Same for magnet leaving solenoid. So the graph is flipped horizontally.……………………………………………………………………………………………………………………… |
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| **Scenario C – Varying Strength of Magnet (What will this affect?)** |
| Default Settings

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| **Parameter / unit** | **Magnitude** |
| Magnet\_Z / m | 0.500 |
| L / m (in **red** for magnet) | 0.100 |
| B / T | 2.470 **🡺 5** |
| v / m/s (in **red** for magnet) | 0.000 |
| Solenoid\_Z / m | –0.500 |
| L / m (in **orange** for solenoid) | 0.000 **🡺 0.500** |
| 30/L  | ∞ |
| v / m/s (in **orange** for solenoid) | 0.000 |

1. **Predict and sketch your expected *E – t* graph in blue/black.**
2. **Click Reset** **.**
3. **Reverse *back* the polarity of the magnet so that North is down again.**
4. **Change solenoid length to 0.500 m.**
5. **Press Enter key.**
6. **Change magnet strength to 5 T.**
7. **Press Enter key.**
8. **Click**  **to run the simulation.**
9. **Copy the simulated graph onto the same axes in red.**
 | **Predicted Graph in Blue/Black*****t******E*** |
| Explanation: Peak has double the height/depth. Previously, E = –dΦ/dt but with 2B and same rate, E’ = –d(2Φ)/dt = 2E……………………………………………………………………………………………………………………… |
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| **Scenario D – Loooong solenoid (What happens while the magnet is falling inside the solenoid?)** |
| Default Settings

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| **Parameter / unit** | **Magnitude** |
| Magnet\_Z / m | 0.500 |
| L / m (in **red** for magnet) | 0.100 |
| B / T | 2.470 |
| v / m/s (in **red** for magnet) | 0.000 |
| Solenoid\_Z / m | –0.500 |
| L / m (in **orange** for solenoid) | 0.000 **🡺 1.000** |
| 30/L  | ∞ |
| v / m/s (in **orange** for solenoid) | 0.000 |

1. **Predict and sketch your expected *E – t* graph in blue/black.**
2. **Click Reset** **.**
3. **Change solenoid length to 1.000 m.**
4. **Press Enter key.**
5. **Click**  **to run the simulation.**
6. **Copy the simulated graph onto the same axes in red.**
 | **Predicted Graph in Blue/Black*****t******E*** |
| Explanation: E = 0 in between the 2 peaks! No change in flux while the magnet is falling inside the solenoid.……………………………………………………………………………………………………………………… |
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This following questionnaire serves as a means for us to solicit your feedback on the effectiveness of the simulation. Your feedback and comments will be used to improve future lessons/simulations. If you have any other feedback to improve the design of this physics virtual laboratory lesson, you can email weelookang@gmail.com.

Thank you for taking the time and effort to complete this questionnaire. 🖒 ☺

Falling Magnet Through Solenoid Simulation (referred to as applet in the following questions)

**Please circle your opinion. SA – Strongly Agree, A – Agree, D – Disagree, SD – Strongly Disagree**

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|  | I enjoyed trying out the different functions of the applet. | **SA** | **A** | **D** | **SD** |
|  | I found the applet difficult to use / There were insufficient instructions. | **SA** | **A** | **D** | **SD** |
|  | After using the applet, I think I now understand better some or all parts of the topic. | **SA** | **A** | **D** | **SD** |
|  | After using the applet, I know more specifically which parts of the topic I still do not understand (I now have questions to ask). | **SA** | **A** | **D** | **SD** |
|  | I am more confused after using the applet.  | **SA** | **A** | **D** | **SD** |
|  | I can apply what I learnt from using the applet.  | **SA** | **A** | **D** | **SD** |

1. What are your views on this inquiry-based lesson? e.g. effective? In what way?

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1. What are your views on the multiple representations? e.g. do you find the graphs useful?

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1. What are the strengths of the lesson?

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1. What are the weaknesses of the lesson?

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1. Is there anything that you feel which could be done to enhance the effectiveness of this lesson? This allows the teacher and programmer to get a sense of the area of improvement, please explain in detail, the more you write, the easier for us to understand. ☺

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