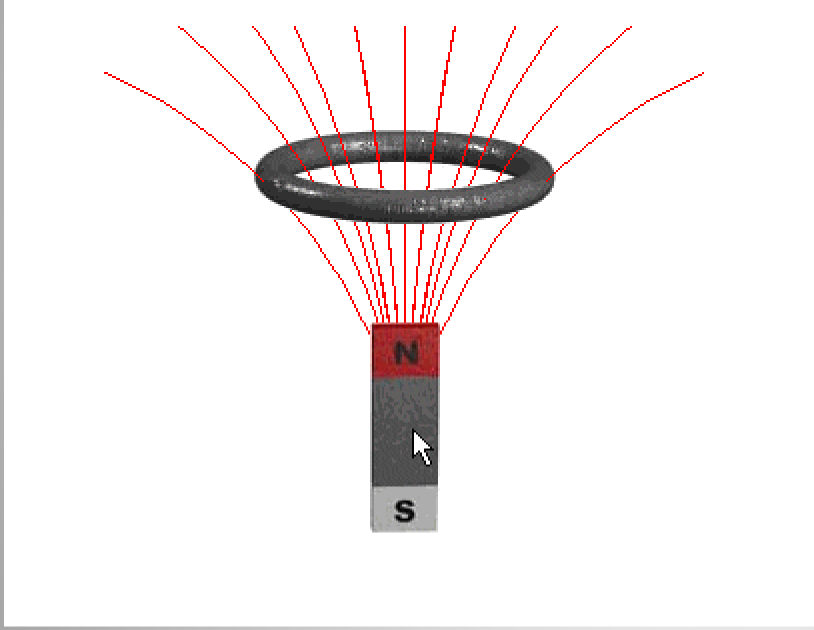
Lenz's Law



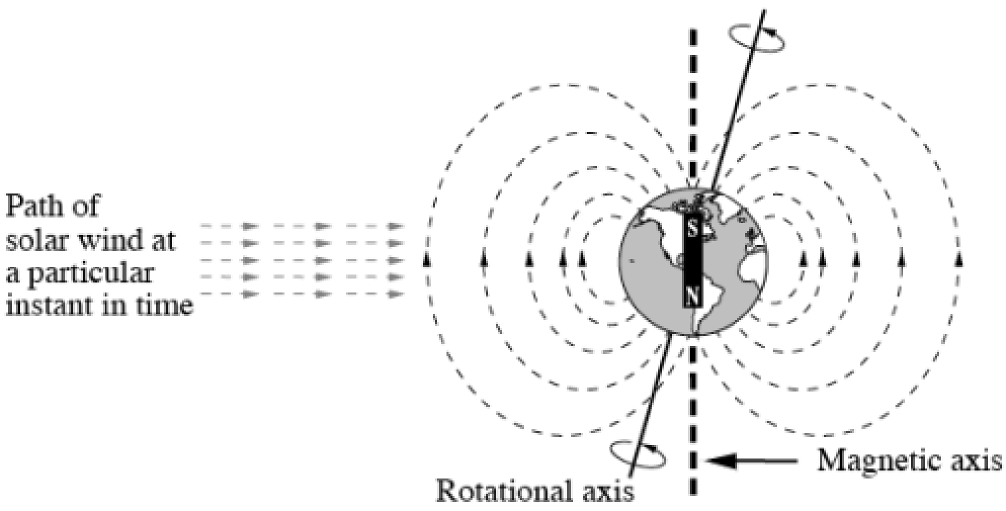
Lesson 8

Diploma Question Alert!

Use the following information to answer the next two questions.

Earth's Magnetic Field

The solar wind consists of particles emitted by the Sun. Some of these particles are charged; therefore, when they enter Earth's magnetic field, they experience a magnetic force. A stream of charged particles travelling with a speed of 8.00×10^5 m/s encounters Earth's magnetic field, as shown below, at an altitude where the field has a magnitude of 1.10×10^{-7} T.



Diploma Question Alert!

Numerical Response

8. Assume that the velocity of the solar wind particles is perpendicular to the magnetic field. The radius of the circular path that protons in a solar wind follow, expressed in scientific notation, is $a.bc \times 10^{d}$ m. The values of a, b, c, and d are ____, ____, ____, and ____ .

(Record your **four-digit answer** in the numerical-response section on the answer sheet.)

Diploma Question Alert!

Numerical Response

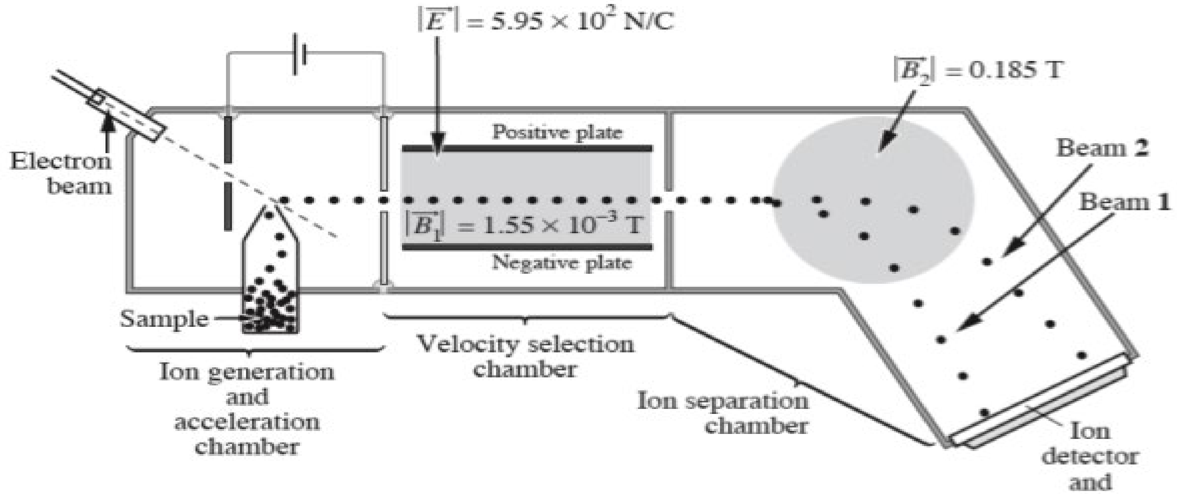
3. A wire that is 75.0 cm long carries a current of 6.00 A. The wire is at right angles to a uniform magnetic field and experiences a magnetic force of 0.350 N. The magnitude of the magnetic field, expressed in scientific notation, is $\boldsymbol{b} \times 10^{-w}$ T. The value of $\boldsymbol{b}$ is __________.

(Record your **three-digit answer** in the numerical-response section on the answer sheet.)

Use the following information to answer the next two questions.

A Mass Spectrometer

A particular lithium sample contains two isotopes. These isotopes are singly charged in an ion generation and acceleration chamber. Since individual atoms are ionized at different points in the acceleration chamber, their speeds vary when they enter the velocity selection chamber. In the velocity selection chamber, the electric field strength is 5.95×10^2 N/C and the magnetic field strength is 1.55×10^{-3} T. The velocity selection chamber allows ions of a certain speed to pass through undeflected. The beam of undeflected ions then enters the ion separation chamber where the magnetic field of 0.185 T splits the beam into two beams. Beam 1 curves through a radius of 0.131 m.



20. The speed of the undeflected ionized lithium ions, Li^+, as they leave the velocity selection chamber is

A. 4.25×10^4 m/s
B. 3.84×10^5 m/s
C. 8.63×10^6 m/s
D. 7.22×10^7 m/s

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Use your recorded answer from **Multiple Choice 20** *to answer* **Numerical Response 7.***

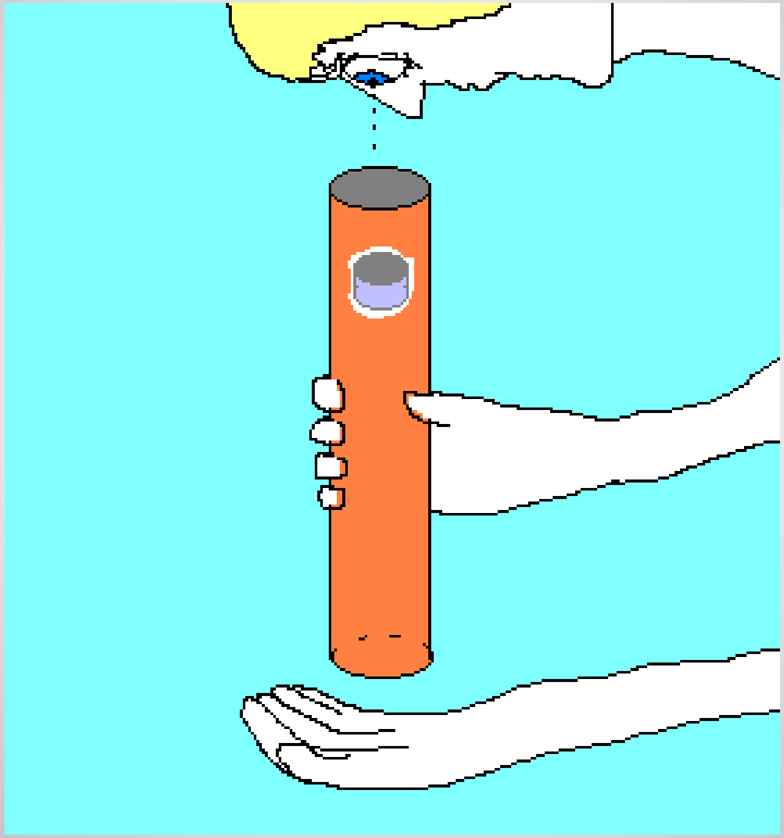
Numerical Response

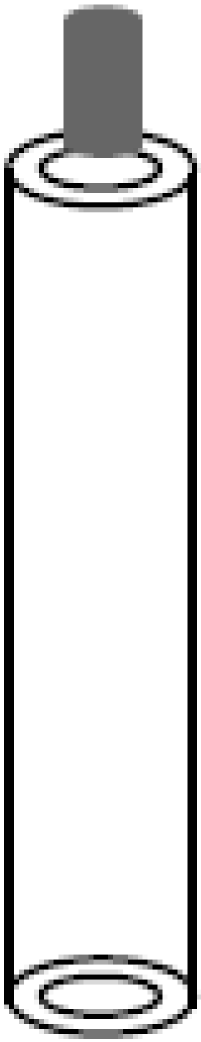
7. The mass of a lithium ion in beam 1, expressed in scientific notation, is $\boldsymbol{b} \times 10^{-w}$ kg. The value of $\boldsymbol{b}$ is __________.

(Record your **three-digit answer** in the numerical-response section on the answer sheet.)

***You can receive marks for this question even if the previous question was answered incorrectly.**

Lenz's Law Demo



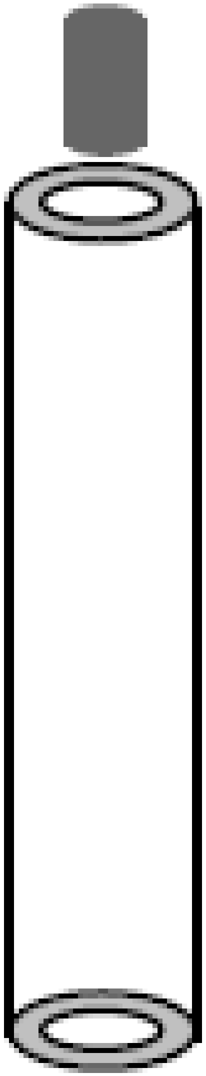


Two magnetic cylinders are dropped through two identical tubes.

One tube is glass, the other a conductor.

The cylinder in the glass tube falls quickly…

the cylinder in the conducting tube falls slowly…



Theories?

Henrich Lenz (1804-1865)

The conducting tube must apply some sort of force on the magnet… but where does it come from?

The answer: INDUCTION.

Theory…

- As the magnet falls through the conductor, we have a situation just like a conductor moving through a B-field
- This creates an induced current in the conductor
- This induced current then produces its own magnetic field, which produces a force on the magnet
- But what direction does this force go in?

An Induction Paradox...

- **Imagine the force was directed downwards...**
- **More force = more speed = more induced current**
- **More induced current = more force = more speed = more induced current**
- **More current = more current = more current = AH HA HA HA HA HAH HAH!!!**

Lenz's Law

- In order to obey the Law of Conservation of Energy, the force must act against the motion of the magnet
- This forms Lenz's Law:
- A magnet moving through a conductor induces a field such to oppose the direction of motion of the magnet.
- Let's put this law to use...

ex) A bar magnet is moved left into a solenoid. What is the direction of:

a) the induced B-field?

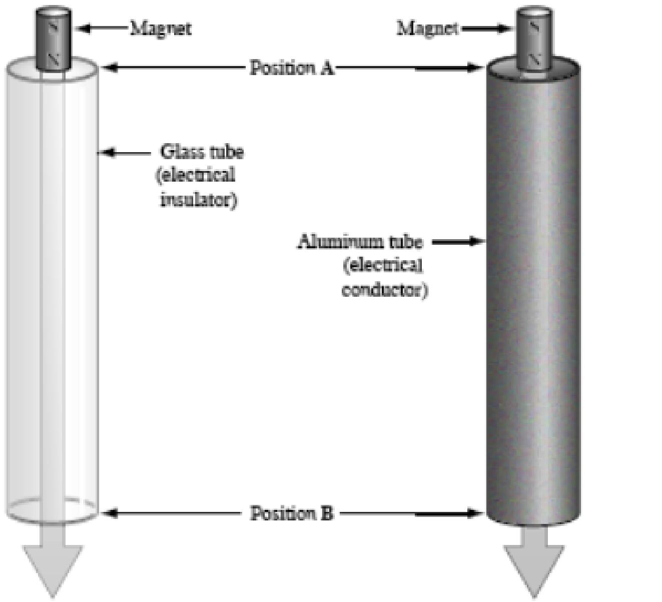
b) the induced current through the ammeter?

Diploma Question Alert!: Take Home Version!!

Use the following information to answer Written Response 2.

Falling Magnet Experiment

Two hollow tubes, one made of glass and the other made of aluminum, are positioned vertically. A student holds identical cylindrical magnets against the outside of the tubes and observe that neither tube attracts a magnet. Based on this observation, the student predicts that each magnet will fall through its respective tube with an acceleration of 9.81 m/s^2. The student and his lab partner then drop the magnets into the tubes from rest at position A, as shown below.



The students make the following observations:
The magnets do not touch the sides of the tubes as they fall. The time for the magnet to fall through the aluminum tube is much greater than is the time for the identical magnet to fall through the glass tube.

	Glass Tube	Aluminum Tube
Mass of magnet (kg)	0.150	0.150
Tube length (m)	0.95	0.95
Time for magnet to fall from position A to position B (s)	0.44	0.76

Written Response—15%

2. Analyze the students' observations from the falling magnet experiment by

- completing the chart below. Include calculations to support the values you write in the chart
- explaining the results of this experiment in terms of Lenz's Law

Clearly communicate your understanding of the physics principles that you are using to solve this question. You may communicate this understanding mathematically, graphically, and/or with written statements.

	Glass Tube	**Aluminum Tube**
Potential Energy of the magnet at position A (J)		
Acceleration of the magnet through the tube (m/s^2)		
Kinetic Energy of the magnet at position B (J)		
Mechanical Energy of the magnet at position A (J)		
Mechanical Energy of the magnet at position B (J)		
Resisting Force on the magnet (N)		