Università di Verona

Corso di Perfezionamento – Metodologico-didattico CLIL
Area Tecnico-Scientifica

Dicembre 2015

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Introduzione

L'argomento di queste unità didattiche è il magnetismo, più precisamente la magnetostatica e le interazioni fra magneti, fra magneti e correnti e fra correnti. Si tratta del primo argomento che viene svolto nel programma di fisica nella classe quinta di liceo scientifico. Essendo anche una parte relativamente semplice, rispetto al resto del programma, è quella che meglio si presta alla metodologia CLIL. Ho scelto la classe quinta in quanto è la riforma stessa che prevede l'insegnamento di una disciplina dell'ultimo anno in lingua inglese.

Dopo l'esperienza CLIL effettuata in questa prima parte dell'anno scolastico, devo ammettere che l'ideale sarebbe quello di iniziare l'esperienza CLIL fin dal primo anno di liceo invece che introdurre questa metodologia solo all'ultimo anno, quando gli studenti sono già orientati verso l'esame di Stato e i programmi da svolgere sono piuttosto impegnativi e ricchi di argomenti. D'altro canto nell'ultimo anno di liceo c'è il grande vantaggio delle competenze linguistiche degli studenti, la maggior parte di loro sono ad un livello fra il B1 e il B2, in qualche caso anche superiore.

Il presente lavoro scaturisce direttamente dall'esperienza fatta in queste ultime settimane con i miei studenti, le attività descritte sono state quasi tutte testate sul campo, con più o meno successo, essendo anche la prima volta che mi trovo a fare una vera esperienza CLIL. Ovviamente molto sarebbe da migliorare, da ampliare ed approfondire.

Il modulo consta di tre unità didattiche, per un totale di 11 ore di lezione senza contare l'ora e mezza di verifica sommativa svolta alla fine del percorso. Mi sono reso conto che il numero di ore impiegato a svolgere gli argomenti di cui sopra è quasi il doppio rispetto a quello impiegato nelle ore, che potremmo definire, di lezione normale in L1. E questo per una serie di motivi, fra i quali mi preme sottolineare l'incremento dell'uso dei laboratori, sia di fisica che di informatica, il procedere lentamente, suddividendo l'argomento in piccoli segmenti e il processo di revisione continua. Il fatto che nella metodologia CLIL sia richiesto un elevato numero di ore a parità di argomenti svolti, rafforza quanto detto in precedenza circa il CLIL nell'ultimo anno di liceo. In ogni caso gli studenti, con mia grande meraviglia, hanno risposto ottimamente sottolineando che questo tipo di approccio sarebbe ideale non solo nel CLIL ma anche nelle discipline in cui non è previsto l'uso di L2.

I testi di riferimento sono stati quelli che ci hanno guidato durante il corso, ossia "The TKT course - CLIL module" di Bentley 2010 e "La lingua straniera veicolare" di Coonan, 2012. Per quanto riguarda la materia specifica, la fisica, ho trovato interessante un volume online dell'OpenStax College, dal titolo "College Physics", (2013), si tratta di un testo di fisica utilizzato in alcuni college degli Stati Uniti, il livello è sicuramente adatto ad una quinta liceo. Questo libro è stato affiancato al libro di testo in italiano che gli studenti utilizzano abitualmente. In questo modo gli studenti hanno a disposizione una buona fonte da cui attingere i vocaboli e le strutture usate in ambito scientifico con grande vantaggio nella"costruzione" della microlingua. Un'altra scelta è stata quella di costruire delle presentazioni con slide (allegate al presente lavoro) che fossero da *guide-line* sia per l'insegnante che per gli studenti, qui si trovano tutti i passi seguiti durante le lezioni, gli esercizi e i problemi di riferimento oltre che i termini specifici. Vale qui la pena di sottolineare un video di riferimento che ritengo estremamente utile, si tratta di una lezione sul campo magnetico di Walter Lewin (https://www.youtube.com/watch?v=X4dXXnUMHbQ), un gigante della didattica, ex professore del MIT. Per quanto concerne l'utilizzo delle applets, che in fisica sono di estrema utilità, il sito www.compadre.org/Physlets è un riferimento molto importante per tutti gli insegnanti di fisica. Infine, ho cercato per quanto possibile di utilizzare materiali autentici (Coonan, La lingua straniera veicolare, pagg. 134, 309) soprattutto nell'attività di laboratorio. La maggior parte del materiale utilizzato è stato creato dall'insegnante e fornito agli studenti o, in qualche caso, costruito direttamente da loro. Tutte le immagini che troviamo nel presente lavoro sono il risultato della nostra attività di laboratorio.

A proposito dell'attività di laboratorio, ho trovato molto utile il sito
http://cse.ssl.berkeley.edu/SegwayEd/lessons/exploring_magnetism/Exploring_Magnetism/index.html
ricco di suggerimenti, soprattutto per quanto concerne la prima unità. Per quanto riguarda la stesura delle relazioni di laboratorio molte idee provengono da
http://writingcenter.unc.edu/handouts/scientific-reports/,
http://abacus.bates.edu/~ganderso/biology/resources/writing/HTWsections.html, e https://www.ncsu.edu/labwrite/,
quest'ultimo è utilissimo perché fornisce direttamente un *form* da compilare guidando lo studente durante la stesura.

Per quanto riguarda la struttura del lavoro ho cercato di attenermi nei limiti del possibile allo schema fornitoci all'inizio del corso. Nella progettazione delle unità ho trovato estremamente utile l'utilizzo del Learning Designer (http://learningdesigner.org/) presentato dalla prof.ssa Cannella, si tratta di un software via web, che aiuta a pianificare l'unità didattica. Le unità didattiche riportano la stessa struttura usata nel software, Learning Designer (LG), avendole scritte e successivamente esportate in word con qualche piccola modifica.

Nello svolgimento dell'unità didattica ho messo in evidenza i momenti in cui c'è un qualche riferimento specifico alla L2 (indicato con "focus on the language"), evidenziando le relative attività con uno sfondo azzurrino. I riferimenti alle slide sono stati fatti richiamando, nelle diverse attività, il numero delle slide relative ad una certa unità con la dicitura (Slide n°) su sfondo grigio. Infine, i riferimenti all'uso delle tecnologie dell'informazione e della comunicazione (TIC) sono evidenziati con la sigla TIC con sfondo azzurrino. Nella parte del Teacher Plan, le risposte ai quesiti e ai problemi e altre sezioni specifiche per l'insegnante sono scritte in blu con carattere *Italic*.

General framework - Planning the CLIL Module

School	Liceo Scientifico
Teacher – responsible for the CLIL project Other teacher involved	Physics teacher
Class involved	5th class
Subjects involved	Physics - English
Level of language competence of the class	B1-B2
Project phases: (Month - phase)	September – October (12 hours)
Resources, locations, materials	Interactive Whiteboard, physics lab, computer lab

General Plan-The CLIL Module

Module title	Magnetism
Teaching Units (Titles)	1. Magnetic field 2. Magnetism and currents 3. Charges in motion
Teacher	Physics teacher
Discipline	Physics
Timeline	six/seven lessons, possibly of two hours each one, between September and October.
Contents (subject)	• Characteristics of the magnetic field, and comparison with the electric field, • interaction between magnets, • Oersted experiment, interaction between currents and magnets, • interaction between currents, • magnetic field produced by a current loop and by a solenoid, • moving charges in a magnetic field, Lorentz's force,
Materials	Lab materials (compass, magnets, solenoids, circuit elements, cathodic tube, ammeter), videos and applets.
Relevant webography	• http://cse.ssl.berkeley.edu/SegwayEd/lessons/exploring_magnetism/Exploring_Magnetism/index.html • www.compadre.org/Physlets (TIC) • https://www.ncsu.edu/labwrite/ (TIC) • http://writingcenter.unc.edu/handouts/scientific-reports/

	• http://abacus.bates.edu/~ganderso/biology/resources/writing/HTWsections.html • http://www.antimoon.com/how/formal-informal-english.htm (formal / informal English) • https://www.youtube.com/watch?v=X4dXXnUMHbQ (lesson by Walter Lewin) • https://padlet.com/ (TIC) • http://learningdesigner.org/ (TIC)
Relevant bibliography	• I Perché della Fisica – dai fenomeni ondulatori ai campi elettrici e magnetici, Consonni, Pizzorno, Ragusa, 2012, Tramontana. • The Feynman Lectures on Physics. Vol. 2, CALTECH, 1989, Addison Wensley Longman • English book: College Physics (2013) by OpenStax College (https://www.openstaxcollege.org/) • The TKT course - CLIL module, Bentley, Cambridge 2010 • La lingua straniera veicolare, Coonan, 2012. • Teaching Other Subjects Through English, Deller, Price, Oxford 2007
Pre-requisites - content	Field and line field definitions, electric field, potential, current, elements of vector analysis.
Pre-requisite language	B1-B2 level
Aims Objectives – content (measurable)	• Understand the meaning of the field and the field lines. • Describe the shape of the magnetic field lines in different configurations. • Understand the difference between the electric field and magnetic field. • Be able to measure the interaction between two magnet bars. • Know that the electricity flowing in wires creates an invisible magnetic field. • Describe the magnetic field produced by a current. • Describe the magnet interaction between magnets and currents and between currents. • Recognize the motion of the charges as a current. • Understand and describe the motion of a charge in an electric and a magnetic field.
Aims Objectives – language (measurable)	• Learn specific vocabulary and idioms of physics and math. • Use of connectives. • Use of the passive form. • Use of linkers. • Distinguish formal / informal English. • Present formally, in front of the class, results or contents, using

	connectors and exchanging point of view.
Objective – study/learning skills	UNIT 1 • Define (Knowledge): the field and the field lines. • Recognize (Knowledge): different field line patterns. • Hypothesize (Application): the field line patterns from magnets shape. • Investigate (Application): find out the field line patterns in different configurations. • Find out/discover (Knowledge): the relation between the force and distance. • Explain (Comprehension): the differences between the electric field and magnetic field. • Apply (Application): the math methods in the data reduction. • Write (Application): a final report. UNIT 2 • Explain (Comprehension): the Oersted experiment, the shape of a magnetic field produced by a current. • Hypothesize (Application): the magnetic field lines shape in different current configurations. • Construct (Application): the Oersted experiment • Predict (Analysis): the interaction between a magnet and a current and between two currents. • Explain the reasons for (Synthesis): the interaction between a magnet and a current and between currents. • Define (Knowledge): the circuitation of a vector field • Write (Application): a formal text • Read (Application): a scientific text • Speak (Application): presentation of results, facts and opinions. UNIT 3 • Explain (Comprehension): the interaction of a charge in motion in an electromagnetic field. • Find out/discover (Knowledge): the trajectory of a charge in motion in an electromagnetic field. • Apply (Application): the Lorentz force in different systems. • Explain the reasons for (Synthesis): the existence of the Lorentz force. • Explain (Knowledge): the structure of the cathode tube and the nature of the cathodic rays. • Speak (Application): presentation of results, facts and opinions.

Cross-curricular objectives	• Solve problems. • Use creativity. • Adopt effective work methods. • Use information and communications technologies. • Achieve his/her potential. • Cooperate with others. • Communicates appropriately.
Procedure (classroom management)	Introduction to the topic by the teacher, lab activities in groups of three, or activities in the classroom in groups of three
Assessment	Lab worksheets, open questions, exercises, lab report, final summative test (exercises and open questions)
Remedial work / reinforcement	Homework, worksheets with tests and exercises, revision in the classroom of the relevant concepts, simplified texts from text books and/or journals (e.g.”the physics teacher”).

MAGNETISM

Teaching Units – Detailed description

Unit 1: Magnetic field

TIME: 4 hours

LOCATION: PHYSICS LAB

Description: the focus of this unit is the magnetostatics. After a short review of the concepts of field and field lines, here we want to analyze the main characteristics of the magnetic field (**B**) and magnetic field lines and measure the interaction between two magnet bars.

Objectives

CONTENT:

- understand the meaning of the field and the field lines,
- describe the shape of the magnetic field lines in different configurations,
- understand the difference between the electric field and magnetic field,
- be able to measure the interaction between two magnet bars.

LANGUAGE:

- learn specific vocabulary and idioms of physics and math,
- use of connectives (page 26, slide 2-9),
- use of the passive form.

Skills

Define (Knowledge): the field and the field lines.
Recognize (Knowledge): different field line patterns.
Hypothesize (Application): the field line patterns from magnets shape.
Investigate (Application): find out the field line patterns in different configurations.
Find out/discover (Knowledge): the relation between the force and the distance.
Explain (Comprehension): the differences between the electric field and the magnetic field.
Apply (Application): the math methods in the data reduction.
Write (Application): a final report.

Teaching-Learning activities

Warming up and motivation phase

Read Watch Listen *10 minutes*
warming up activity: two videos in order to introduce the beauty and the utility of the magnetic field. The first video (w1) is about the polar aurora, without comments, it illustrates the amazing scenarios in the polar regions during the aurora. The second one (w2) is a short introduction about the magnetic resonance, with a comment easy to follow.

Read Watch Listen *15 minutes*
short introduction about the history of the magnetism (the compass, Gilbert as the first scientist who tried to explain the magnetism phenomenon) and the chemical structure of the natural magnets (magnetite). Then the presentation of the compass and the magnetic field of the Earth showing the students two applets from PHYSLET PHYSICS (w3) (TIC), the students are invited to use these applets at home.

Introduction and Practice

Discuss *25 minutes*
working in groups of three, answer to these fundamental questions:
What is a field?
What is a field line?
At the end one student for each group writes on the white board the answers, then an open discussion with the teacher in order to find out the correct definitions. In this phase the teacher asks the students to summarize the characteristics of the gravitational field and electric field as a revision of the previous knowledge.

HOMEWORK: summarize the characteristics of the studied fields stressing the differences that there are between them (max 200 words).

Focus on the language *10 minutes*
The teacher shows the students the basic glossary (page 25) for this topic and the connectors (page 26) useful to write the answers, in the next activity, and the report.

Read Watch Listen *10 minutes*
in the lab, the teacher shows and explains the instruments and material that the students have to use in the following lessons.

Investigate *30 minutes*
in groups of three, answer to the questions on the worksheet by means experiments performed with the lab material.

*Group:*______ *names:*____

*Date:*__________________

1. *What do you notice about the interaction of the bar magnets you were given?*

2. *What materials interact with the magnets and how do they interact?*

   Interacts with magnets:

   Does not interact with magnets:

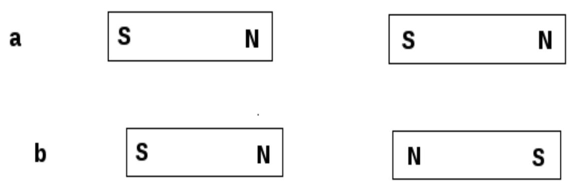
   What do all the materials that interact with the magnets have in common?

3. *What happens when you bring a compass near a magnet? How does it depend on where you place the compass?*

4. *Draw what you hypothesize the magnetic field will look like around a single bar magnet. Include arrows that point in the direction the compass points(north red by convention).*

5. *Draw how it looks from your measurements with the compass.*

6. *Draw what you hypothesize the magnetic field will look like around two bar magnets in the new configurations a) and b).*



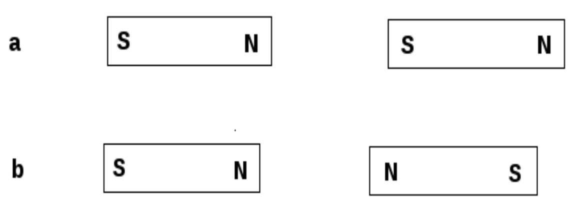
7. *Draw how they look from your measurements with the compass:*

8. *What did you observe when you sprinkled the iron filings over the paper covering the bar magnet? Draw what you observed.*

9. *Can you explain why the iron filings behaved that way?*

10. *Do you see the same patterns as you did with the compass tracings?*

11. *Draw what you expect to see when you sprinkle iron filings over two bar magnets in the new configurations a) and b).*



12. *Draw what you did, in fact, see with your two magnets in the new configurations. How were your expectations the same or different?*

HOMEWORK: Analyze the worksheet you filled in the lab and write down the specific words you have learnt today.

Produce *20 minutes*
Singularly: Write down the main characteristics of the magnetic field lines you found with the previous observations and compare the answers with the other students of the group.

Practice and consolidation

Read Watch Listen *5 minutes*
the teacher explains the aim and the procedure in order to find out the interaction between two magnet bars.

Discuss *10 minutes*
a little discussion about the interaction between magnets, is an interaction similar to that of the electric charges?

Practice *30 minutes*
the students in groups of three realize the experiment and take measures.

Investigate *15 minutes*
with the obtained measures, the students try to find out the relation of the exerted force between the magnets.

Focus on the language *10 minutes*
The teacher reminds the students the used forms to write reports (above all the passive form) and shows an example of report (w4). Then the LabWrite (TIC) on-line editor (by NC State University) is shown to students (w5).

HOMEWORK: write down the report following the template (page 33) that is given (deadline 15 days).

Summing up phase

Discuss *25 minutes*
discussion about the results obtained in the previous experiment with the analysis of the employed math methods, eventually the teacher introduces the logarithm linearization and the data interpolation and their English terms (math idioms, page 27), this part is fundamental in order to analyze the data and to write the report correctly.

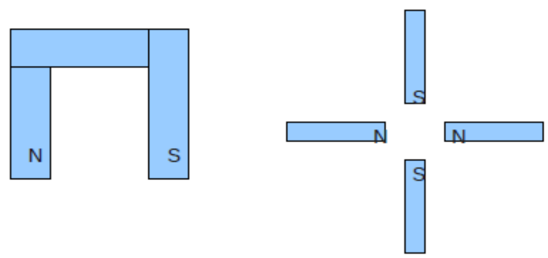
Read Watch Listen *15 minutes*
The teacher summarizes the field and field lines definitions and the characteristics of the magnetic field and magnetic field lines.

Testing (formative and self assessment)

10 minutes

Answer to these questions:

1) Indicate the poles of the magnet bars when necessary and draw the field lines in the following cases:



2) Compare the field lines of the electric dipole with those of the magnetic bar (magnetic dipole): write your conclusions.

Unit 2: Magnetism and currents

TIME: 4 hours

LOCATION: CLASSROOM

Description: in this lesson we'll discover the connection between magnetism and currents. The Oersted experiment. Magnetic field produced by currents. Then we will analyze the interaction between magnet and a current, and between currents.

Objectives

CONTENT:

- know that the electricity flowing in wires creates an invisible magnetic field,
- describe the magnetic field produced by a current,
- describe the magnet interaction between magnets and currents and between currents.

LANGUAGE:

- extend the glossary and idioms of physics and math,
- use of linkers (page 26, slide 2-9),
- distinguish formal / informal English.
- present, in front of the class, results or facts.

Teaching-Learning activities

Skills

Explain (Comprehension): the Oersted experiment, the shape of a magnetic field produced by a current.
Hypothesize (Application): the magnetic field lines shape in different current configurations.
Construct (Application): the Oersted experiment
Predict (Analysis): the interaction between a magnet and a current and between two currents.
Explain the reasons for (Synthesis): the interaction between a magnet and a current and between currents.
Define (Knowledge): the circuitation of a vector field.
Write (Application): a formal text.
Read (Application): a scientific text.
Speak (Application): presentation of results, facts and opinions.

Warming up and motivation phase

Read Watch Listen *10 minutes*
an incredible observation: the Oersted experiment.
The students observe the experiment performed by the teacher.

Introduction and Practice

Investigate *15 minutes*
the students, working in group of three, can analyze the experiment and try to find out the shape of the magnetic field lines.

Discuss *5 minutes*
What happens to the magnet field if we close the current in a loop?

Read Watch Listen *10 minutes*
Remark that a current creates a magnetic field and the shape of the field lines.
Then describe a solenoid.

Discuss *5 minutes*
What happens to the magnetic field if we close the solenoid in a loop?

Read Watch Listen *10 minutes*
the teacher shows the students an experiment about a wire with a current i immersed inside a magnetic field

Discuss *10 minutes*
Brainstorming: how to describe the force acting on the wire?

Practice and consolidation

Read Watch Listen *15 minutes*
Now we know that a current produces a magnetic field and so it is reasonable to think that there must be an interaction between a wire and the external magnetic field.
show the first part of the video of Lewin (w6).

Investigate *15 minutes*
in groups of three, the students try to find out a possible relation of the force exerted between a currents wire and an external magnetic field.

Discuss *10 minutes*
students and teacher summarize the results obtained during the investigation in order to find out the law, this is a fundamental relation.

Investigate *5 minutes*
Starting from the force acting on the wire, find the dimensions of the magnetic field.

Read Watch Listen *15 minutes*
a review of the circuitation definition.

Produce *10 minutes*
working in groups of three, the students have to find out the circuitation of B field in the case of a linear current.

Investigate *15 minutes*
In groups, investigate the possible interaction between two parallel currents.

Summing up phase
Produce *15 minutes*
The students, in groups of three, have to answer to the following questions.

1. Do monopoles exist? Why/Why not?
2. Is the Earth like a giant magnet? Who said that?
3. Is the Earth north pole a north magnetic pole? Why/Why not?
4. What is the famous Oersted experiment? What is the conclusion?
5. Describe the right hand rule.
6. A straight line current perpendicular to a B field experiences a force, what is its direction?
7. What is the B unit? Express this unit in fundamental units.
8. What happens if an Aluminum sheet is placed between two parallel current wires?

We assume 8 groups. Each group has only one question correspondent to the number of the group. The group 1 asks to group 2 the first question. If the group 2 is not able to answer the question is for the group 3, and so on. Every time that a group answers to the question gains points. The group 8 ask the question to the group 1. This is a formative assessment and it is useful to review the main topics of the two units. Then the groups produce a summary of this unit.

Focus on the language *20 minutes*
The teacher shows eight tables (page 26, slide 2-9) about the linkers (adding ideas, expressing cause, sequencing an argument, sequencing a narrative, making conditions, expressing contrast and expressing

purpose) in order to give the students more instruments to write the report (Unit 1) and to describe the following homework.
The students, singularly, try to find out the linkers and the passive form from a given text (page 33).
The teacher shows some examples of written formal/informal English (w7).

HOMEWORK: an amazing toy (Slide 13), describe the toy and explain how it works in max 300 words, see the video (w8).

Remedial work

30 minutes

Give back the students the previous corrected worksheets and exercises related to the Unit 1, and shows them the mistakes, then give them other exercises from College Physics (b1) to solve in pairs in classroom and at home singularly.
The class is divided in groups of three. Peer education with the teacher support. Then the students have to solve two standard exercises.

The wire carrying 400 A to the motor of a commuter train feels an attractive force of 4.00×10^{-3} N/m due to a parallel wire carrying 5.00 A to a headlight. (a) How far apart are the wires? (b) Are the currents in the same direction?

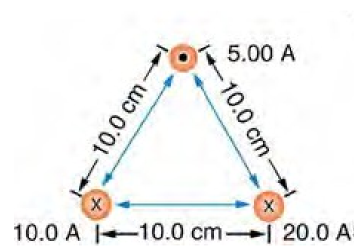
Calculate the size of the magnetic field 20 m below a high voltage power line. The line carries 450 MW at a voltage of 300,000 V.

Testing (formative and self assessment)

15 minutes

Singularly: solve these problems

1) Find the direction and magnitude of the force that each wire experiences in picture by, using vector addition.



2) What is the angle between a wire carrying an 8.00 A current and the 1.20 T field it is in, if 50.0 cm of the wire experiences a magnetic force of 2.40 N? (b) What is the force on the wire if it is rotated to make an angle of 90° with the field?

Unit 3: Charges in motion

TIME: 3 hours

LOCATION: COMPUTER LAB & CLASSROOM

Description: in this lesson we will study the motion of an electric charge into an electric and magnetic field. The prerequisites are: current, magnetic field and field lines, the interaction between a magnetic field and a current and the interaction between a charge and an electric field.

Objectives

CONTENT:

- Recognize the motion of the charges as a current.
- Understand and describe the motion of a charge in an electric and a magnetic field.

LANGUAGE:

- extend the glossary and idioms of physics and math,
- present formally, in front of the class, results or contents, using connectors and exchanging points of view.

Skills

Explain (Comprehension): the interaction of a charge in motion in an electromagnetic field.
Find out/discover (Knowledge): the trajectory of a charge in motion in an electromagnetic field.
Apply (Application): the Lorentz force in different systems.
Explain the reasons for (Synthesis): the existence of the Lorentz force.
Explain (Knowledge): the structure of the cathode tube and the nature of the cathodic rays.
Speak (Application): presentation of results, facts and opinions.

Teaching-Learning activities

Warming up

Read Watch Listen *15 minutes*
warming up and revise activity: a part of the video by Lewin (w6)

Practice *10 minutes*

we need to review the action of a current wire and the magnetic field B: $\vec{F} = i\,\vec{l} \times \vec{B}$
by means the java applet (w9) (TIC).

<u>Focus on the language</u> 5 minutes
Exchanging points of view
The teacher writes on the white board some typical expressions used to express the exchange of points of view.

Introduction and practice
Read Watch Listen 10 minutes
the derivation of the force $\vec{F} = q\,\vec{v} \times \vec{B}$ (Slide 2-3)

Investigate 10 minutes
in pairs the students have to find out the trajectories of the particles depending on the electric charge, in the specific case where the velocity (**V**) and the magnetic field (**B**) are perpendicular by means the java applet (w10) (TIC). (Slide 4-5)

Read Watch Listen 5 minutes
a moving charge in a magnetic field B, the general case, see the video (w11).

Produce 10 minutes
(self evaluation activity)
In groups of three, answer to the following questions concerning the previous video:

Group N°:______ names:____

1. *Write the equation of the force acting on a moving charge into a B field.*
2. *How is defined the direction of the force given by the previous equation?*
3. *What happens to the charge if its velocity is parallel to B?*
4. *What happens to the charge if its velocity is anti-parallel to B?*
5. *What happens if the velocity of the charge is perpendicular to B?*
6. *What happens if the velocity forms an angle α (where $0<\alpha<\pi/2$) with B?*
7. *What is the pitch?*
8. What is the helicoidal motion?

Each group presents the answers to the rest of the class, all the students have to speak!

Practice and consolidation

Investigate *10 minutes*

The teacher show the students the cathodic tube and illustrates the elements and the structure.
then: in groups of three, the students try to deflect the cathodic rays with a magnet bar, they have to discover the nature of these rays and the acting force. (Slide 7)

Discuss *10 minutes*

what is the force of a charge moving in an electric and magnetic field?

$\vec{F} = q\vec{E} + q\vec{v} \times \vec{B}$ (Slide 8)

Practice *5 minutes*

an exercise (Slide 9)

HOMEWORK: in group of three, build the experiment seen in the first Java applet (w9) following the instructions and report template on the school e-learning platform. Complete the work in 10 days.

summing up phase

Produce *25 minutes*

in the computer lab, working in groups of three: creation of a **padlet page** about the interaction between currents and/or the Lorentz force and its applications (TIC).

HOMEWORK: in groups of three: joint down a short **ppt presentation** (6 slides) about the Lorentz force and its applications (TIC).
Then share the presentations on the http://www.slideshare.net/ platform or an equivalent one (TIC).

Testing (formative and self assessment)

10 minutes

Singularly: solve these problems

1) A proton moves at 7.50×10^{7} m/s perpendicular to a magnetic field. The field causes the proton to travel in a circular path of radius 0.800 m. What is the field strength?

2) (a) What voltage will accelerate electrons to a speed of 6.00×10^{7} m/s ? (b) Find the radius of curvature of the path of a proton accelerated through this potential in a 0.500 T field.

Remedial work

60 minutes

Every group has to present the ppt presentation (the previous homework) to the rest of the class, so the

students can review the main contents of this unit. Every student has to present 2 slides.
Give back the students the previous corrected worksheets and exercises related to the unit 2, and show them the mistakes, then give them other exercises from College Physics (b1) to solve in pairs in classroom and at home singularly.

Testing

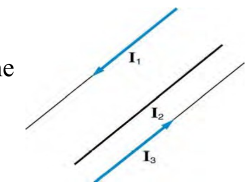
Final summative assessment (90 min in the next lesson)

Answer to <u>four</u> of the following questions:

1) A charged particle moves in a straight line through some region of space. Can you say that the magnetic field in that region is necessarily zero?

2) A cosmic ray proton approaches the Earth from outer space along a line toward the center of the Earth that lies in the plane of the equator. In which direction will it be deflected by the magnetic field of the Earth? What about an electron? A neutron?

3) You have three parallel wires on the same plane, as in the picture, the current runs in the outer ones in opposite directions. Can the the middle wire be repelled or attracted by both of them? Explain.



4) Draw gravitational field lines between 2 masses, electric field lines between a positive and a negative charge, electric field lines between 2 positive charges and magnetic field lines around a magnet. Qualitatively describe the differences between the fields and the entities responsible for the field lines.

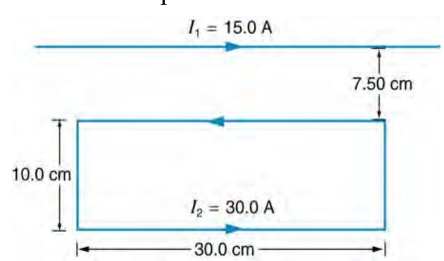
5) Why does a uniform magnetic field cause uniform circular motion for a moving charged particle?

6) Use the principles of uniform circular motion to find expressions for both the period T and the velocity of a moving charged particle in a uniform magnetic field.

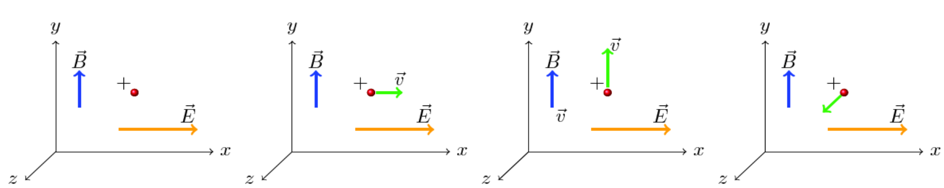
Solve <u>two</u> of the following problems

7) An electron moving at 4.00×10^3 m/s in a 1.25T magnetic field experiences a magnetic force of 1.40×10^{-16}N. What angle does the velocity of the electron form with the magnetic field? There are two answers.

8) The picture shows a long straight wire next to rectangular current loop. What is the direction and magnitude of the total force on the loop?



9) Determine the direction of the Lorentz force for each situation below.



Webography & Bibliography

w1 https://www.youtube.com/watch?v=aa5Lc6BXIFA

w2 https://www.youtube.com/watch?v=H5q79R9C-mk

w3 http://www.compadre.org/Physlets/electromagnetism/

w4 http://www.northeastern.edu/physics/wp-content/uploads/Sample-Lab-Report.pdf

w5 https://www.ncsu.edu/labwrite/

w6 https://www.youtube.com/watch?v=X4dXXnUMHbQ

w7 http://www.antimoon.com/how/formal-informal-english.htm

w8 https://www.youtube.com/watch?v=J9b0J29OzAU

w9 http://www.walter-fendt.de/ph14e/lorentzforce.htm

w10 http://www.lon-capa.org/~mmp/kap21/cd533capp.htm

w11 https://www.youtube.com/watch?v=fwiKRis145E

b1 College Physics (2013) by OpenStax College (https://www.openstaxcollege.org/)

b2 English 3 step 1, inlingua (2013)

Appendix

A – Glossary

From College Physics - 2013 (b1)

B – Connectors and discourse markers

C - Math idioms

D – Slides

Unit 1

Unit 2

Unit 3

E - Report template

<table><tr><td>

Title

group
authors
date

Abstract
(max 100 words)

Introduction
(text, formulas, pictures, diagrams)
(max 600 words)

Setup & Procedures
(text, formulas, pictures, diagrams)

Data & Analysis
(text, formulas, tables, pictures, diagrams)

Conclusion
(max 300 words)

References
(bibliography, webgraphy)

</td></tr></table>

F – Other Material

The following texts is given as examples of the use of connectives and linkers and the passive form in the scientific reports.

http://adamcap.com/schoolwork/magnetic-fields-lab/

Conclusion
During part one of the experiment, magnetic field strength was measured as a function of radial distance from a conductor. First, a piece of polar graph paper with concentric circles starting at a diameter of 0.5 cm increasing in increments of 0.5 cm to 10 cm was punched through a rigid aluminum conductor at the center of the concentric circles. The paper was placed on the plastic table of the apparatus and was aligned using a compass so that the parallel lines on the sheet were pointing north. The paper was then secured to the apparatus using tape. The high amperage DC power supply was connected in series with a high power resistor and the aluminum wire at the side and on top of the apparatus. The magnetic field sensor was zeroed and the DC power supply was set to 7 A. With the current on and kept constant, the magnetic field strength was recorded at each circle on the polar graph paper by holding the sensor in line with the parallel lines on the sheet and so that the white

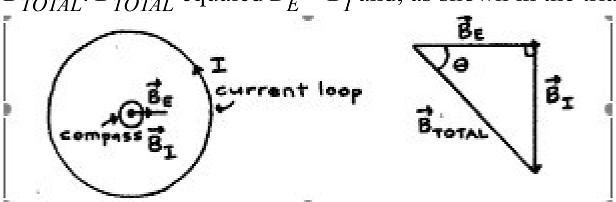
dot on the sensor was on the left and at a 90^o angle with the parallel lines pointing north. The magnetic field strength was recorded using Vernier Lab Pro. This value was recorded along with the respective radius.
Graphical Analysis was used to plot B vs. 1/R and perform a linear trend. The resulting slope was 9.2×10^{-7} Tm and the correlation was 0.9734. It was somewhat difficult to get accurate readings at the smaller radii, which negatively affected this correlation. The slope from this plot in comparison to the value of $\mu_o I / 2\pi$, 1.4×10^{-6} Tm, yielded a percent difference of 41%. The data followed the expected trend of decreasing in magnetic field strength as the radius increased. Possible sources of error include the difficulty of aligning the sensor perfectly along the radius of each circle, and it was also a challenge to get an accurate reading from the sensor as the readings kept jumping around. Additionally, if the sheet was not perfectly aligned northward, there would be interference from the earth's magnetic pull which would have affected the readings.

http://www.clemson.edu/ces/phoenix/labs/223/magforce/

Our experimental setup is shown in Figure 5 and is described as follows. A permanent magnet assembly, comprised of six removable horseshoe magnets, is placed on a triple-beam balance, and the balance is then zeroed. A variable current source is connected to the current balance assembly, which has at one end a removable wire loop etched onto a circuit board. This wire loop is then placed into the permanent magnet assembly so the wire loop is perpendicular to the magnetic field but is not touching the magnets. Then, when a current flows through the wire loop, a magnetic force is created. Since the wire loop is stationary the magnetic force acts on the permanent magnet assembly causing its weight to either increase or decrease depending on the direction of the current and the orientation of the magnetic field. The change in the magnet assembly's weight is due to the magnetic force given by Equation 5.

http://blogs.baruch.cuny.edu/imagazine/2010/02/16/experiment-4-magnetic-field-of-the-earth-by-elizabeth-fanciullo/

Earth's magnetic field has both a horizontal and vertical component. However, in our experiment we only wanted to obtain the horizontal component, which we called B_E. To do so, we set up a system that consisted of a loop of wire, which carried an electric current created by a battery. The current loop behaves much like a bar magnet, in that one side of the loop acts like the north magnetic pole and the other side acts like the south magnetic pole. As a result, when we placed the compass at the center of the loop, we made sure to rotate the loop so that its plane was parallel to the horizontal component of the Earth's magnetic field. In other words, we made sure the north pole of the compass pointed not only at 0° (in the horizontal direction), but also pointed directly in line with the current loop. When we turned on the current, it flowed through the loop and produced a second magnetic field, which we called B_I. (Experiments have revealed that electric currents always produce magnetic fields.) The "right hand rule" of physics to determine the direction of the magnetic field (point the thumb in the direction of the current, then curl fingers around the wire to reveal the direction of the field) showed the magnetic field flowed perpendicular to the current in the loop. Because the magnetic field flowed perpendicular to the loop, it also flowed perpendicular to Earth's north direction (because the horizontal component of Earth's magnetic field was parallel to the plane of the loop). The new magnetic field, B_I, forced the compass to deflect from North and rotate by an angle, θ, which essentially created a magnetic field triangle, where the line connecting B_E and B_I represented the total magnetic field, B_{TOTAL}. B_{TOTAL} equaled $B_E + B_I$ and, as shown in the triangle below, $\tan\theta$ equaled B_I / B_E.



Since we wanted to determine the magnetic field of the Earth, we solved for B_E, which gave us the equation: $B_E = B_I / \tan\theta$.
In order to calculate B_I, we used the formula which gave the magnitude of the magnetic field at the center of the current loop: $B_I = N\mu_0 I / 2R$. N equaled the number of loops, which, in our case, was a consistent 15. μ_0 was the constant, $4\pi \cdot 10^{-7}$, I was the current reading, and R was the radius of the current loop, which we measured as 0.1 meters.

By adjusting the rheostat (which increased or decreased resistance and, thereby, increased or decreased current) on the circuit box, we obtained various currents flowing through the wire and, therefore, various angles at which the compass deflected from North. We used the angles and current readings to calculate our experimental values for the horizontal component of the magnetic field of the Earth.

[...] Next, we turned on the multimeter and set it to 200 mA (milliAmps). In order to make the compass deflect from North and rotate by an angle θ, we needed to increase or decrease the resistance and, thereby, increase or decrease the current flowing through the loop (which produced the second magnetic field). So, we simply pushed down and turned the rheostat on the circuit box until we noticed the compass needle move. Since we knew each mark on the compass represented 5°, we continued to turn the rheostat until the compass needle was exactly in line with one of the 5° incremental marks. We simultaneously observed the multimeter and, when the compass needle reached a readable angle, we recorded both the angle and the current given by the multimeter at that point. After recording our first observation, we made three more observations by turning the rheostat until the compass settled at three more readable angles. We then read and recorded the currents at those angles. By completing all our observations, we could calculate our experimental values for the horizontal component of the Earth's magnetic field. For each observation, we first calculated the second magnetic field produced, B_1, using the formula mentioned in the previous section: $B_1 = N\mu_0 I / 2R$. Since we set the multimeter to milliAmps, we made sure to multiply our current reading, I, by 10^{-3}. By determining B_1, we could then calculate the magnetic field of the Earth, B_E, also using the formula mentioned in the previous section, where θ was the angle at which the compass deflected from North: $B_E = B_1 / \tan\theta$. Once we completed calculating the magnetic field of the Earth for all four trials, we calculated our average, deviations, average deviation and percent average deviation. Finally, we used our average to calculate our percent error and compare our experimental value for the Earth's magnetic field to the accepted value (at New York City), which was $2 \cdot 10^{-5}$ Tesla.

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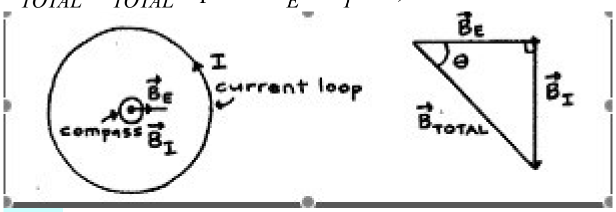

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Useful applets

- www.compadre.org/Physlets
- http://www.mhhe.com/physsci/physical/giambattista/magnetic/magnetic_field.html
- http://www.falstad.com/vector3dm/