EARPHONES

TEACHER'S GUIDE

October 2007

WORKING DOCUMENT
IMPORTANT NOTES

1. Before starting to read this guide, I invite you to read the overview of the task. Indeed, the overview will allow you to better situate this LES within the program. A glimpse of the student booklet appears to the right of the pages of this document.

2. This learning situation has been designed especially for the applied science and technology (AST) course.

3. You will find an evaluation grid for this LES in annex 1 of this guide.

4. Five periods are foreseen for this LES:
   - Periods 1, 2 and 3: complete the observation cards and review in plenary session.
   - Period 4: complete analysis card, principles diagram and explanations of functionality.
   - Period 5: study of anomalies and reflection.

5. The number of students per team has been set at four in order to limit the number of stations. It is very difficult to find more than eight anomalies in an earphone’s function. In addition, a greater number of stations (2 x 8 stations) makes managing the lab very cumbersome.

6. Practically, 3 other documents will help you to prepare your operation.
   - A manufacturing range will help you make 9 sets of earphones (one perfectly functional and 8 others containing anomalies).
   - A list and pictures of the materials required to bring to term the manipulations associated to the theoretical notions observations cards.
   - A short «PowerPoint» presentation that may be used in the fourth period. It presents pictures of different parts of a functioning set of earphones. It can be played continuously on a projector.

7. In annex 2, you will find a list of suppliers for the more specialised materials.
IMPORTANT NOTES (CONTINUED)

The theoretical notions seen here can be approached in many ways. Each teacher will bring his own methodology to the matter. In addition, the materials available in each institution may differ substantially. We nonetheless propose a way to work – it is up to you to decide.

➢ In the fourth year of high school some latitude must be left to the student. That is why the student is not guided much by the LES itself. The teacher's presence is primordial. He must move from station to station to share his knowledge and know-how. Without his presence, the students may become stymied and get discouraged. Different reference texts should also be available (for instance old physical sciences or I.T.T. books). It is even possible to supply each station with a card resuming the targeted theoretical notions (photocopies, for example). The student would then only need to select the useful information.

➢ The material necessary for each station is specified in the student booklet. In addition, the PowerPoint presentation called “Earphones theory materials” presents, by means of pictures, a detailed list of materials to use.

Suggested timetable for the observation cards.

Period 1 --> Introduction and 3 stations
Period 2 --> 4 stations
Period 3 --> 1 station and plenary session (teacher lecture)

STATION 1

Here, the student must check the conductivity of several samples through contact. They can proceed directly with the help of a multimeter in «conduction» mode, or by connecting the sample in series in a circuit composed of a power source and a light bulb.

Instructions

1. Form teams of 4 people.
2. Go to the work station designated by the teacher.
3. At this station, the team must become familiar with the theoretical notions by means of the centre called “Theoretical notions observation card”.
4. The team must then go to the next work station in order to be faced with new theoretical notions (each team will have to work through all 8 stations set up in the lab).
5. When all the teams have finished their observations, a set of earphones will be placed at each workstation. You must then analyse these earphones by means of the centre called “Components analysis card”.
6. Next, you must complete the section called “Principles diagram and explanation of functionality”.
7. The team must now locate the defect in the earphones at this station by completing the table called “Study of anomalies”.
8. Finally, the team will move to the next station to be faced with a different set of defective earphones (each team will work through all 8 stations set up in the lab).

THEORETICAL NOTIONS OBSERVATION CARD

<table>
<thead>
<tr>
<th>Station</th>
<th>Objectives: differentiating between conductors and conductors</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Multi meter (optional)</td>
</tr>
<tr>
<td></td>
<td>1 battery (9 V)</td>
</tr>
<tr>
<td></td>
<td>1 battery connector (9 V)</td>
</tr>
<tr>
<td>1</td>
<td>2 wires</td>
</tr>
<tr>
<td></td>
<td>1 light bulb (9 V)</td>
</tr>
<tr>
<td></td>
<td>15 samples (see below)</td>
</tr>
</tbody>
</table>

My observations about theoretical notions (what I need to remember)
STATION 2
At this station, the student must check the conductivity by introducing different samples into the circuit. While measuring the current by means of an ammeter, the student will determine the conductivity of the samples.

<table>
<thead>
<tr>
<th>Station #</th>
<th>Notes</th>
<th>Materials</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Objective: Identify the factors that influence the conductivity of a conductor. Track: Through which samples does the current pass best?</td>
<td>* 1 -2-0 battery (1.5 V) * battery holder * 3 wires * ammeter * 3 samples of different material (steel, copper, nickel-aluminum) * 3 samples of different length (10, 50, 100 cm) * 3 samples of different size (R26, R32, R18)</td>
</tr>
</tbody>
</table>

My observations about theoretical notions (what I need to remember)

STATION 3
During these manipulations, the student must:

- Determine the configuration of the magnetic field by sprinkling iron filaments on the cardboard, being careful to place the magnet under it.
- Find the direction of the magnetic field with the help of the compass.
- Identify the north and south poles of the magnet with the compass.

Here the magnet must be fairly sizable in order to generate a good sized pattern in the iron filaments.

<table>
<thead>
<tr>
<th>Station #</th>
<th>Notes</th>
<th>Materials</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>Objective: To determine the configuration and the direction of the magnetic field of a permanent magnet. Track: Do not put the filaments directly on the magnet. The colored side of the needle of the compass is a north pole. How is the compass pointed close to the magnet? Where is the north pole of the magnet? How are the filaments positioned over the magnet?</td>
<td>* 1 straight magnet * 1 compass * 1 -2-0 battery for iron filaments * 1 piece of cardboard to hold the filaments</td>
</tr>
</tbody>
</table>

My observations about theoretical notions (what I need to remember)
STATION 4
During these manipulations, the student must:

- Determine the configuration of the magnetic field by sprinkling iron filaments on the cardboard, being careful to place the magnets under it.
- Find the direction of the magnetic field with the help of the compass.
- Identify the north and south poles of the magnet with the compass.
- Identify the forces involved (attraction and repulsion).

Here, the student should place the magnets side by side. The student must also study what happens between the two magnets (when there is repulsion and attraction).

STATION 5
During these manipulations, the student must:

- With a compass, detect the magnetic field around a straight wire through which an electrical current is running.
- Also to be observed by means of the compass is the direction of the magnetic field. A small diameter compass (about 2 cm) is preferable, since these small compasses are more sensitive and will react to weak magnetic fields better.

Even if in this case there is no north pole, we ask that the student try to find it. Eventually, he should understand that, in this case, a magnetic field may be detected without being able to identify the poles. The right hand rule may be approached with the students. As this notion may be difficult to understand, it may be presented in the third period lecture.
STATION 6
During these manipulations, the student must:
- With a compass, detect the magnetic field around a solenoid through which an electrical current is running
- With a compass, observe the direction and poles of the magnetic field.

The right hand rule may be approached with the students. As this notion may be difficult to understand, it may be presented in the third period lecture.

STATION 7
During these manipulations, the student must:
- Verify the effect of the core of a solenoid by trying to attract the greatest number of paper clips from the box.

During this experiment, the tension may be set at the maximum for the power source (for example 10 volts).
STATION 8
During these manipulations, the student must:

- Verify the effect of a variable number of whorls on the number of paper clips attracted.

Here, a soft iron core must be used for each solenoid. The current must remain constant throughout the experiment (2A, for example).

PLENERY SESSION
Now is the time to have a plenary session concerning the theoretical notions discussed. Comprehension of these notions must be ascertained. Without a thorough grasp of the theoretical notions, the students will have difficulty proceeding with the rest of the project. A lecture is even recommended to explain the more complex notions (the right hand rule, for instance).
**IMPORTANT NOTES**

It would be preferable not to allow the consultation of documentary sources at the beginning of this activity. As the structure of our earphones is different from those presented in the literature, these sources may hinder the student's research. His previous knowledge as well as the study of the preceding theoretical notions should allow him to complete a good part of the analysis card. A consultation of the documentary sources could be allowed afterwards to complete the work. A short looped “PowerPoint” presentation may be used at this stage. It presents pictures of a functional set of earphones.

**Completed analysis card**

<table>
<thead>
<tr>
<th></th>
<th>Components</th>
<th>Functions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1/8 connector</td>
<td>• Allows the reader and earphones to be electrically connected.</td>
</tr>
<tr>
<td>2</td>
<td>Wire</td>
<td>• Conducts the electrical signal moving the sound towards the earphones.</td>
</tr>
<tr>
<td>3</td>
<td>Casing</td>
<td>• Protects the earphones (wire, magnet...)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Acts as a sound board</td>
</tr>
<tr>
<td>4</td>
<td>Cover (membrane)</td>
<td>• Vibrates to generate sounds</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Allows sound to escape by the holes</td>
</tr>
<tr>
<td>5</td>
<td>Magnet stand</td>
<td>• Keeps the magnet close to the solenoid's magnetic field.</td>
</tr>
<tr>
<td>6</td>
<td>Permanent magnet</td>
<td>• Generates a magnetic field close to the solenoid.</td>
</tr>
</tbody>
</table>
| 7  | Solenoid or bobbin  | • Generates a variable magnetic field in relation to the intensity and the direction of the current.  
|    |                     | • The solenoid can be attracted or repelled by the magnet and thus, vibrates.
**IMPORTANT NOTES**

The structure of our earphones is different from those usually found in the literature. Normally, the solenoid is mobile and the permanent magnet is fixed. The light weight of the solenoid limits the inertia of the system allowing it to vibrate more freely and quickly. In our earphones, the permanent magnet is mobile and affixed to the membrane, and the solenoid is fixed. This choice was not made lightly. Indeed, we wanted earphones we could take apart and that are impervious to students who are less than respectful for the materials. In class, the wires of a solenoid do not withstand being taken apart. In addition, since the weight of our solenoid is comparable to the small permanent magnet, there was no advantage to retaining a mobile solenoid.

**Example of a principles diagram**

![Diagram of earphone components]

**Examples of explanations of the above diagram**

- When the current circulates in one direction in the solenoid, it generates a north pole facing the north pole of the magnet. A force of repulsion appears and the membrane is propelled towards the right. The membrane pushes the air, thus creating a compression zone.

- When the current circulates in the other direction in the solenoid, it generates a south pole facing the south pole of the magnet. A force of attraction appears and the membrane is propelled to the left. The membrane then pulls the air in front of it, creating a depression zone.

- It is these compression and depression zones that generate the sound waves.
N.B. Each team should have an ohmmeter (multi-meter) at its disposal. The notion of resistance however, should be introduced.

<table>
<thead>
<tr>
<th>#</th>
<th>Anomalies and resistances</th>
<th>R (Ω)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>None</td>
<td>Between 8 and 14</td>
</tr>
<tr>
<td>1</td>
<td>The solenoid wire is not varnished.</td>
<td>Ideally 0</td>
</tr>
<tr>
<td>*2</td>
<td>The magnet is too far from the solenoid.</td>
<td>Between 8 and 14</td>
</tr>
<tr>
<td>*3</td>
<td>The number of whorls is insufficient.</td>
<td>Below 8</td>
</tr>
<tr>
<td>4</td>
<td>The solders are imperfect because of the varnish.</td>
<td>Between 8 and 14</td>
</tr>
<tr>
<td>5</td>
<td>There is a short circuit in the connector.</td>
<td>Ideally infinity</td>
</tr>
<tr>
<td>*6</td>
<td>The cover has no holes.</td>
<td>Between 8 and 14</td>
</tr>
<tr>
<td>*7</td>
<td>The movement of the membrane (cover) is blocked (the magnet is firmly leaned on the solenoid).</td>
<td>Between 8 and 14</td>
</tr>
<tr>
<td>8</td>
<td>There are no magnets (false magnets).</td>
<td>Between 8 and 14</td>
</tr>
</tbody>
</table>

* Means these earphones work. You must find the anomaly that makes them perform poorly.

N.B. The resistances are given for ~500 whorls of #32 wire.

<table>
<thead>
<tr>
<th>#</th>
<th>Suggested repairs</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>None</td>
</tr>
<tr>
<td>1</td>
<td>Make the solenoid again using a varnished wire.</td>
</tr>
<tr>
<td>*2</td>
<td>Bring the magnet closer to the solenoid.</td>
</tr>
<tr>
<td>*3</td>
<td>Make the solenoid again using more whorls.</td>
</tr>
<tr>
<td>4</td>
<td>Re-solder the connections (scrape off the varnish).</td>
</tr>
<tr>
<td>5</td>
<td>Locate and eliminate the short circuit.</td>
</tr>
<tr>
<td>*6</td>
<td>Drill many holes in the cover.</td>
</tr>
<tr>
<td>*7</td>
<td>Shorten the pin in order to move the magnet further from the solenoid.</td>
</tr>
<tr>
<td>8</td>
<td>Add a functional magnet.</td>
</tr>
</tbody>
</table>

* Means these earphones work. You must find the anomaly that makes them perform poorly.
This last section has several aims:

- Skim the general fields of training and axes of development chosen.
- Skim the targeted cross curricular competency.
- Reflect upon the cultural resources.
- Make a short reflective and meta-cognitive flyover of the LES.
### ANNEX 1 (Evaluation Grid)

**Student’s name:**

**Learning situation:** **EARPHONES**

**Development of competency 2**

<table>
<thead>
<tr>
<th>Evaluation criteria</th>
<th>1-2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
</table>
| **Formulation of an appropriate questioning.**
Pages 2, 7 and 11 of the student booklet. | The student transcribes the mandate without proposing any questions related to the analysis of the earphones. He recognises the most obvious components of the earphones. | The student proposes questions in relation to the analysis of the earphones. He wonders about the function of the main components of the earphones. | The student proposes a complete questioning to diagnose the anomalies in the earphones. He wonders about all the components and their relationship to one another. | The student proposes a complete questioning concerning the function of the earphones and foresees a link with the anomalies. He wonders about the ethical and social aspects related to the use, repair, and consumption of the technical object presented. |
| **Pertinent use of the concepts, laws, models and theories of science and technology.**
Page 8 of the student booklet. | Following the experiment, the student recognizes the components of the earphones he studied previously without relating them. | Following the experiment, the student identifies some components of the earphones and attributes functions to them in relation to theoretical notions. | Following the experiment, the student identifies the most pertinent components of the earphones and attributes functions to them in relation to theoretical notions. | Following the experiment, the student identifies the components of the earphones and systematically attributes functions to them based on theoretical notions. |
| **Production of pertinent explanations, solutions or interventions.**
Pages 9 - 10 of the student booklet. | The relationships established are not pertinent to the identified components. His diagrammed and written explanations make it difficult to understand how the earphones work. | The relationships established are adequate for the identified components. He supplies a brief explanation with the help of a principles diagram and theoretical notions that allow for a partial understanding of how the earphones work. | The relationships established are pertinent for all the identified components. He supplies a complete explanation of how the earphones work with the help of a principles diagram and theoretical notions. | The relationships established are detailed and pertinent for the identified components. He supplies a detailed written and diagrammed explanation to understand how the earphones work. |
| **Adequate justification for explanation, solutions or interventions made.**
Pages 10 - 11 of the student booklet. | The student identifies the obvious defects in the analysed earphones and suggests adequate repairs. | The student identifies the major defects in the analysed earphones and suggests adequate repairs, sometimes based on theoretical notions. | The student explains all the defects in the analysed earphones and suggests adequate repairs based on theoretical notions. | The student explains all the defects in the analysed earphones and suggests adequate repairs based on theoretical notions. He proposes modifications to improve their function. |
ANNEX 2 (suppliers for specialised materials).

Nickel-chromium wire, enamelled (varnished) or unvarnished copper wire
Prolabec
2213 le Chatelier Street
Laval (Quebec) H7L 5B3
CANADA

Telephone: (450) 682-5118 or (800) 556-5226
Facsimile: (450) 682-6468 or (800) 556-8182


Strong magnets
Lee Valley Tools Ltd.
P.O. Box 6295, Station J
Ottawa, ON K2A 1T4

Telephone: (613) 596-9202
Facsimile: (613) 596-9502