



## Demonstrator # 15

# Influence of respiratory rate on the effectiveness of exercise

### TEACHER NOTES

Activity title:

**InLOT help us get the lot! (III)**

- Influence of respiratory rate on the effectiveness of exercise

Subject:

**Physics - Class IX**

Student age:

**14-16 years**

Estimated duration:

**2x50 minutes (50 minutes, for data collecting, 50 minutes for data processing)**

Science content

InLOT System

Fluids mechanics

Learning objectives

Lesson is valuable because creatively exploit knowledge like fluids mechanics, human physiology, practical skills through non-formal learning contexts applicability, such as sport.

At the end of this lesson students will be able to:

⇒ to use creatively INLOT system in applied contexts which simultaneously exploit the knowledge of physics and the biology

To explore the physical reality testing AM on handy moving devices

Inquiry-based character

The student will enhance their work skills specific scientific investigation and discovery activities geared for this type of learning:



*1. Identify Questions for Scientific Investigations*

- Identify testable questions
- Refine/refocus ill-defined questions
- Formulate hypotheses

*2 Design Scientific Investigations*

- Design investigations to test a hypothesis
- Identify independent variables, dependent variables, and variables that need to be controlled
- Operationally define variables based on observable characteristics
- Identify flaws in investigative design
- Utilize safe procedures
- Conduct multiple trials

*3 Use Tools and Techniques to Gather Data*

- Gather data by using appropriate tools and techniques
- Measure using standardized units of measure
- Compare, group, and/or order objects by characteristics
- Construct and/or use classification systems
- Use consistency and precision in data collection
- Describe an object in relation to another object (e.g., its position, motion, direction, symmetry, spatial arrangement, or shape)

*4 Analyze and Describe Data*

- Differentiate explanation from description
- Construct and use graphical representations
- Identify patterns and relationships of variables in data
- Use mathematic skills to analyze and/or interpret data

*5 Explain Results and Draw Conclusions*

- Differentiate observation from inference
- Propose an explanation based on observation
- Use evidence to make inferences and/or predict trends
- Form a logical explanation about the cause-and-effect relationships in data from an experiment

*6 Recognize Alternative Explanations and Predictions*

- Consider alternate explanations
- Identify faulty reasoning not supported by data

*7 Communicate Scientific Procedures and Explanations*

- Communicate experimental and/or research methods and procedures
- Use evidence and observations to explain and communicate results
- Communicate knowledge gained from an investigation orally and through written reports, incorporating drawings, diagrams, or graphs where appropriate

Applied technology (if any)

In order to do so the KLiC project uses an innovative sensor data collection tool, namely the InLOT system ([www.inlot.eu](http://www.inlot.eu)) that consists of the following modules:

- *SensVest* - a vest, equipped with various sensors, designed to carry components that

measure and transmit physiological data to the base station.

- **Leg and Arm Accelerometer** - small devices attached to the leg and/or arm that enable the 3-D measurement of the acceleration for the leg and/or arm.

**Ball Accelerometer** - a ball that has embedded an accelerometer measuring three dimensions and a communication unit that enables the transmission of data packets to the base.

- **Base Station** - responsible for the collection of all transmitted data

- **User Interface Software** - user friendly interface, designed with a pedagogical frame of mind, that enables the process of data and actions such as plotting data on a graph or creating a mathematical model to fit the data.

User details can be found in Annex 10.1.

#### Materials needed

- InLOT system
- PC
- Physical kit: fluids mechanics
- Worksheet (Annexes 10.1, 10.2 and 10.3)

#### Discussion guide

**Anticipation:** Unit summary: The Fluids Mechanics

**Essential Question:** *How physics helps us to better understand the surrounding world?*

#### Before a project approach

Before using a project approach, the high school students will review the principles of Newtonian dynamics, will discuss techniques for working with INLOT system, then write an essay about the use of physical knowledge in sports. Essays will be between three and five pages and will be noted. Essays will be evaluated in terms of Newtonian dynamics harnessing knowledge about techniques for working with INLOT system discussed above.

#### After a project approach

After the scenario proposed sequence no. 10 has been completed, indicated that students apply the theme and new skills to the situations described by their essays. Students will be invited to explore the questions: a) *How physics helps us to better understand the surrounding world?* and b) *How that gives us the performance perspective?*. Students will analyze how science and technology in performance are mutually supportive and not just athletes

#### Building knowledge

##### Teaching strategy

- ☐ The teacher monitors and advises business groups, provides support points, support students in their approach.
- ☐ Use project method
- ☐ Integrate knowledge and skills achieved an adequate framework for reflection.

#### Reflection / Consolidation

**Evaluation method:** gallery tour

#### Assessment

- ✓ summative
- ✓ formative

## Annex 10.1

### Using accelerometer

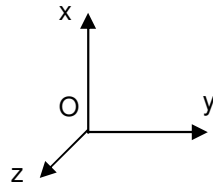


Photo accelerometer

#### Reference directions of accelerometer

##### What accelerometer (AM) measures?

- The frames of reference in which the experiments are conducted are non-inertial, so it is necessary to simplify the model; therefore we encourage the selection of appropriate experimental contexts secondary level approach.
- It appears that AM measures, momentary, relative acceleration in non-inertial frames of reference. Generally, according to kinematics in non-inertial frames of reference:

$$\vec{a}_{rel} = \vec{a}_{abs} - (\vec{a}_{cor} + \vec{a}_{transp}) \quad (0.1.)$$

$$m \cdot \vec{a}_{rel} = m \cdot \vec{a}_{abs} - m \cdot (\vec{a}_{cor} + \vec{a}_{transp}) \quad (0.2.)$$

$$m \cdot \vec{a}_{rel} = \vec{F} + \vec{F}_c \quad (0.3.)$$

-Accelerometer (AM) measures the difference between the momentary gravitational component (reference direction Ox of AM), plus centrifugal momentary acceleration (if a change of direction of motion) and momentary acceleration of movement of AM in that direction.

$$\vec{a}_x = \vec{g}_x + \vec{a}_{cfx} - \vec{a}_{mx} \quad (0.4.)$$

1. where  $\vec{F}_c$  is supplementary forces.

Particularly, there are situations (eg, a ball suspended at rest relative to the earth, but relative to a man sitting on a rotating wheel, the ball appears to be in rotation), where it may happen that the body viewed from S does not any force, but still to see him moving accelerated relative to S' due to supplementary force,  $\vec{F}_c$ :

$$a_{abs} = 0 \Rightarrow \vec{F} = 0 \rightarrow \vec{F}_c = m \cdot \vec{a}_{rel} \quad (0.5.)$$

An important class of reference frames is the object's own frame or frame-related rigid object moving uniformly force from their frame (eg the man and the object (= S') are resting on the rotating disc, and the object is caught in a spring). In such frames the object is evident in the rest ( $\vec{a}_{rel} = 0$ ), although there is a real force  $\vec{F}$ . In this case:  $\vec{F} + \vec{F}_c = 0 \rightarrow \vec{F}_c = m \cdot \vec{a}_{rel}$ . That supplementary force is equal but opposite to the real force, so it is equivalent to the Newtonian inertial force.

**Supplementary forces are fictitious forces that should be added to the real forces to ensure the validity of the II<sup>nd</sup> principle of Newtonian mechanics in non-inertial frames.** These are not forces of interaction, we can show the body that produces them, so it doesn't applies the III<sup>rd</sup> principle of Newtonian mechanics.

Where: -  $a_x$  is the value measured on test direction (relative acceleration)  
 -  $g_x$  is the component of gravity acceleration on test direction  
 -  $a_{cfx}$  is the component of centrifugal acceleration on test direction  
 -  $a_{mx}$  is the acceleration of movement (accelerometer and body together) on test direction (acceleration of transport).

$$a_y = g_y + a_{cfy} - a_{my} \quad (0.6.)$$

$$a_z = g_z + a_{cfz} - a_{mz} \quad (0.7.)$$

If the motion is made on certain direction, relatively to the reference directions of AM, then the previous relations are wrote on each component of the acceleration measured by accelerometer ( $\neq 0$ ).

All measured values are fractions of  $g$  (gravity acceleration), expressed relative to the value of  $g$  for which was calibrated AM.

#### Cases:

I.  $a_{mx} = 0$  (AM is at rest, set on the object whose motion is studied, or in rectilinear and uniform motion on test axis, chosen as the Ox axis)

$$\Rightarrow a_x = g_x + a_{cfx} \quad (0.8.)$$

• More if  $a_{cfx} = 0$

$$\Rightarrow a_x = g_x \quad (0.9.)$$

II.  $g_x = 0$  ( the test axis is in a perpendicular plane on vertical )

$$\Rightarrow a_x = a_{cfx} - a_{mx} \quad (0.10.)$$

• In addition if  $a_{cfx} = 0$

$$\Rightarrow a_x = -a_{mx} \quad (0.11.)$$

This is the method of determining the acceleration of motion of AM/the object bounded on AM.

#### What we can measure with the accelerometer in the laboratory / practical applications?

• *Angles:* AM in resting, sat alongside a surface makes an angle  $\alpha$  with the vertical;

$$a_x = g \cdot \sin \alpha \Rightarrow \alpha = \arcsin \frac{a_x}{g} \quad (0.12.)$$

- Acceleration of translational motion on:
  - Axis in the horizontal plane regardless of the gravity component
  - Axis of the other plane, but taking into account the gravity component
- Acceleration of complex motion (rotation and translation)

Annex 10.2

ASSESSMENT TOOLS

Scores for project evaluation

1 = Criterion is not fulfilled	3 = Criterion is fulfilled in good measure
2 = Criterion is met only slightly	4 = The criterion is fully met

1. All team members undertake collaborative activities by completing the steps in processing aid given to them and collect data for one of the roles within the team

1 2 3 4

2. Each member fulfills the role it has in the team. Team members' work together to achieve a quality presentation

1 2 3 4

3. Presentation made meet the recommended structure.

1 2 3 4

4. Explanation contained in the presentation is enlightening to the public

1 2 3 4

5. Project presentation is eloquent and enlightening for the audience participating.

1 2 3 4

6. The manner of presentation is attractive and involving public

1 2 3 4

7. Team members are open to public questions and formulate answers all questions pertinent to public

1 2 3 4

8. Introducing the team roles demonstrates that members are knowledgeable in all fields covered by the project.

1 2 3 4

9. Team members speak out loud, communicates a very clear presentation of content, and establish eye contact with audience.

1 2 3 4

10. Team members provide additional explanations to the public request, using the flip chart

1 2 3 4

**Completion:**

**Note:** The lesson is built valuing prior knowledge acquired in different learning contexts and integrates communication skills, collaboration skills, investigation, practical skills, but also interpersonal and social skills, artistic skills and expression.

## Annex 10.3 AUXILIARY FOR TEACHING

### 10.I. Kicking life into Classroom: InLOT help us get the lot! (III) - Influence of respiratory rate on the effectiveness of exercise



The secret of performance... You MUST HAVE:

Ambition  
Tenacity  
Strategy  
Training  
Attitude  
Rhythm  
Timing

... From Physics, Biology, Chemistry to Physical education, all as part of a highly own performance.

### 10.II. Into Lab with InLOT:

Modelling physical phenomena: study of biological parameters	Principle method
<p><b>10.II.A. Heart rate</b></p> <p>The heart is a powerful muscle pumping blood throughout the body. It is located in the chest behind the sternum, with a shape like a pear (to healthy adults to approximate size fist size).</p> <p><b>Heart Revolution:</b> passing blood from atria to ventricles and then into the vascular tree, together with phenomena which determine and accompany this movement of blood, called heart revolution (fig. 10.1.).</p> <p>The heart is a <b>pump inlet - removal</b>, blood flow is possible due to its rhythmic contractions. Revolution starts with cardiac diastolic filling during atrial fibrillation, venous blood.</p> <p><b>Heart rate (arterial)</b> is a peripheral manifestation of mechanical activity of the heart, consisting of an expansive wave periodic synchronous with ventricular</p>	<p><b>10.II.A. Heart rate</b></p> <p>Heart contractions are approximately 60-100 per minute and approximately 100 000 contractions per day.</p> <p>Heart rate sensor allows recording and storage platform allows InLOT these data correlated with those provided by other sensors.</p> <p><b>Heart Revolution:</b> The revolution takes 0.8 seconds and includes cardiac contraction or systolic atrial fibrillation, which takes 0.1 seconds, the contraction of the ventricles, or ventricular systolic, which takes 0.3 seconds, relaxation (recovery) of all hearts, or diastole general which takes about 0.4 seconds</p>



expulsion, palpation of an artery seen in the underlying hard tissue.

**Heart pulse frequency** is assessed by counting pulses for a minute.

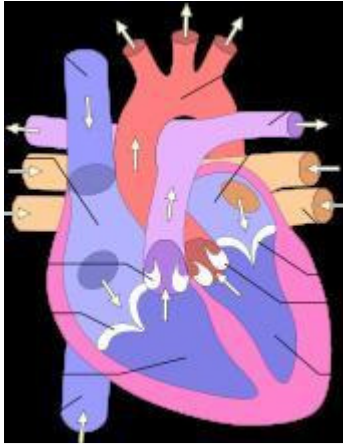


fig. 10.1. Heart function

### 10.II.B. Breathing frequency

The chest expansion (a process involving diaphragm muscle contraction inspiring and down), lungs swell like an accordion bellows extension and relaxed atmosphere enters the alveoli (inspiration), and by tightening and lifting the chest diaphragm arches, air is expelled from the lungs (exhalation).

The main centres of respiratory reflexes are found in the brainstem. They are located in the bulb and are composed of an inspiratory and an expiratory component. The deck is another centre called pneumotaxic centre (central regulator of bulbar centres). All centres have a bilateral organization.

When centres are inspiring work by motor nerves to muscles are sent inflows inspired falling into contraction. Inspiring rhythmic cluster is inhibited by expiratory centres into action; muscles do not receive incentives and relax, producing real exhalation.

Breathing reflex adjustment ensures that start inflows of pulmonary alveoli and respiratory centres reached via nerves vague. A cold shower may cause reflex briefly stop breathing (apnea), nasal mucosa and trachea excited causes, by reflex, sneezing and coughing, respiratory acts are considered modified.

Through pneumotaxic center, upper floors

### Heart pulse frequency:

With rare exceptions equals heart contractions frequency, ranging between 60-90/min.

### 10.II.B. Breathing frequency

The lungs are usually filled with 3 liters of air, which adds a 0.5-liter common inspiration, making permanently to renew sixth of lung air. Man resting circulate 8 liters of air per minute to 16 liters a sedentary activity, walking 24 liters, the effort (running) 50 liters. One day circulate 24,000 liters of air volume varies with the type of activity and constitutional. In an effort can be ventilated average 3.5 liters of air in inspiration and a great effort, with 5.5 liters training. Highest ventilation is achieved by athletes who are rowing. Breath adjusts the body needs oxygen. Whenever they are raised (increased muscle activity, exercise, fever, some diseases), respiratory frequency increases.

Sensors allow western thoracic breathing frequency recording and storing such data InLOT platform, linked to those of other sensors.



nerve involved in breathing regulation and adaptation. Cortex controls and coordinates the respiratory function. The emotions, breathing frequency increase on the contrary, strong fear can cause a short stop.

### **10.II.C. Body temperature**

Body temperature is kept constant (homoeothermic) through physiological adjustment.

Thermoregulation is a complex function under the command of the central nervous system, primarily the hypothalamus (gray ensemble formations located in the third ventricle in the centre of the brain).

Body temperature is the result of the combined phenomena of production and heat loss. Heat, plus heat received from the outside, resulting in intracellular chemical reactions and muscle contractions.

Spontaneous loss is through the skin, it is favoured by surface vasodilatation (dilation of blood vessels in the skin) and sweat, followed by evaporation of sweat.

### **10.II.C. Body temperature**

Body temperature has averaged 37 degrees Celsius. It normally ranges from 36.5 degrees Celsius (by 3 o'clock in the morning) to 37.2 degrees Celsius (by 6 pm). Western heat sensor allows record body temperature and storing such data InLOT platform coupled with those provided by other sensors.

## STUDENT WORKSHEET

Activity title:

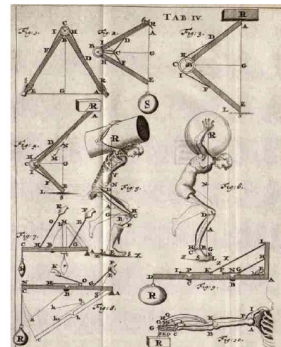
**InLOT help us get the lot! (III) - Influence of respiratory rate on the effectiveness of exercise**

Introduction

If we look closer at live animal biology problems, we see many natural phenomena: blood flow, pumps, pressure, etc..

*Alfonso Borelli School (1608-1679): the human body is a machine, try to explain and draw conclusions about the nature of various medical malady.*

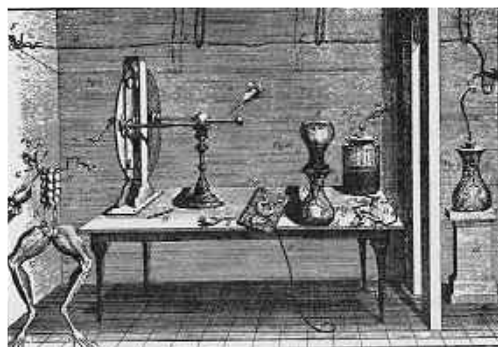
*Could today be considered as belonging to medical biophysics..*



*Studies by Leonardo da Vinci (1452-1519) to investigate the mechanical principles of the flight of birds in order to build a flying machine could be considered today bionic*



*Galvani's experiments (1737-1798) which demonstrates the direct connection of electricity "physical" and electrophysiological phenomena.*



Thinking about the question

**10.I. Kicking life into Classroom: InLOT help us get the lot! (III) - Influence of respiratory rate on the effectiveness of exercise**



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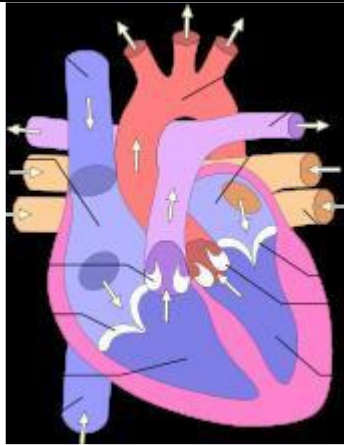


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<p><b>10.II.C. Body temperature</b> Body temperature is kept constant (homoeothermic) through physiological adjustment. Thermoregulation is a complex function under the command of the central nervous system, primarily the hypothalamus (gray ensemble formations located in the third ventricle in the centre of the brain). Body temperature is the result of the combined phenomena of production and heat loss. Heat, plus heat received from the outside, resulting in intracellular chemical reactions and muscle contractions. Spontaneous loss is through the skin, it is favoured by surface vasodilatation (dilation of blood vessels in the skin) and sweat, followed by evaporation of sweat.</p>	<p><b>10.II.C. Body temperature</b> Body temperature has averaged 37 degrees Celsius. It normally ranges from 36.5 degrees Celsius (by 3 o'clock in the morning) to 37.2 degrees Celsius (by 6 pm). Western heat sensor allows record body temperature and storing such data InLOT platform coupled with those provided by other sensors.</p>
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**Materials needed**

- InLOT system
- PC
- Worksheet

**Safety**

Follow the rules of labour protection in the physics laboratory.

**Investigation**

Name and surname of the participants: 1. \_\_\_\_\_, 2. \_\_\_\_\_, 3. \_\_\_\_\_, 4. \_\_\_\_\_, 5. \_\_\_\_\_

Category  student;  teacher;  athlete;  other

Age: \_\_\_\_\_, gender:  M,  F

<b>Experimental determinations</b>	<b>Action plan:</b>
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<p><b><u>initial parameters</u></b> <b>The initial frequency of the heart pulse of the student is:</b> <input type="text" value="F&lt;sub&gt;heart pulse - initial&lt;/sub&gt; = _____ /min."/></p> <p><b>The initial breathing frequency of the student is:</b> <input type="text" value="F&lt;sub&gt;breath - initial&lt;/sub&gt; = _____ / min."/></p> <p><b>The initial body temperature of the student is:</b> <input type="text" value="t&lt;sub&gt;initial&lt;/sub&gt; = _____ °C"/></p> <p><b><u>test no. 1: slow respiratory rate</u></b> <b>The frequency of the heart pulse of the student is:</b> <input type="text" value="F&lt;sub&gt;heart pulse 1&lt;/sub&gt; = _____ /min"/></p> <p><b>The breathing frequency of the student is:</b> <input type="text" value="F&lt;sub&gt;breath. 1&lt;/sub&gt; = _____ / min."/></p> <p><b>The body temperature of the student is:</b> <input type="text" value="t&lt;sub&gt;1&lt;/sub&gt; = _____ °C"/></p> <p><b><u>test no. 2: fast and shallow respiratory rate</u></b> <b>The frequency of the heart pulse of the student is:</b> <input type="text" value="F&lt;sub&gt;heart pulse 2&lt;/sub&gt; = _____ /min"/></p> <p><b>The breathing frequency of the student is:</b> <input type="text" value="F&lt;sub&gt;breath. 2&lt;/sub&gt; = _____ / min."/></p> <p><b>The body temperature of the student is:</b> <input type="text" value="t&lt;sub&gt;2&lt;/sub&gt; = _____ °C"/></p>	<p>Determinations are made, of course, in the reference accelerometer system, by interface InLOT using A3, heart pulse rate, respiration frequency and body temperature controllers.</p> <ol style="list-style-type: none"><li>1. First of all, is made an initial determination of the frequency of heart rate, respiration rate and body temperature of the student</li><li>2. then, perform a set of exercise (running, pushups, squats), to record changes in the frequency of your heart rate, respiration rate and body temperature of the student</li><li>3. Set of exercises is done by each student, 3-4 times, with breaks for exercises registration sites set</li><li>4. In each test, the student shall impose different rates of breathing: a slow and deep and shallow b.fast, etc.).</li><li>5. Measure the temperature, pulse and respiratory rate for each particular type of breathing</li><li>6. It is noted that the two types of breathing is better (lower pulse) for each of the students elected</li><li>7. Construct graphics of the frequency variation in time of the heart rate, respiration rate and body temperature of the student, by comparing the three situations.</li><li>8. Discuss observations from graphics for the same student.</li><li>9. Record charts heart pulse rate, respiration rate and body temperature of two students of the same age, but performance / different physical condition.</li></ol>
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**Analysis**

Analyze the causes of friction and what impact they had on the outcome of the experiment.

**Further investigation**

1. **Relevance.** Students will reflect and find answers identifying possible practical role of the work done, the benefits of science and technology on life in general, the place of science in society, the social role of researcher.
2. **Connection with the real world.** Students will reflect on the practical character of their project, they will understand the importance of experimental data and the practical benefits of using the results .



## Assessment

**Gallery Tour:** Students will prepare oral presentations to appropriate audiences, which are accompanied by multimedia presentations, brochures and websites. These products must identify current community needs and resources and provide acceptable solutions. Thus, the task turns into a learning project in support of the community, creating an authentic purpose and making a connection with the real world through community.

*Evaluation criterion:*

1. All team members undertake collaborative activities by completing the steps in processing aid given to them and collect data for one of the roles within the team
2. Each member fulfills the role it has in the team. Team members' work together to achieve a quality presentation
3. Presentation made meet the recommended structure.
4. Explanation contained in the presentation is enlightening to the public
5. Project presentation is eloquent and enlightening for the audience participating.
6. The manner of presentation is attractive and involving public
7. Team members are open to public questions and formulate answers all questions pertinent to public
8. Introducing the team roles demonstrates that members are knowledgeable in all fields covered by the project.
9. Team members speak out loud, communicates a very clear presentation of content, and establish eye contact with audience.
10. Team members provide additional explanations to the public request, using the flip chart