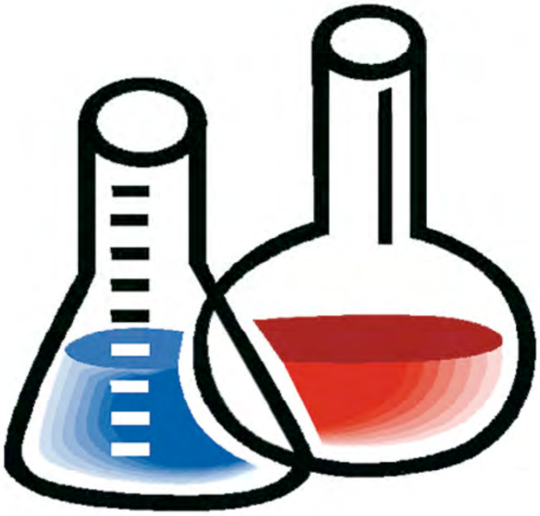
centre de
développement
pédagogique
pour la formation générale
en science et technologie

FIND THE SOLUTION!



GUIDE FOR THE TEACHING AND TECHNICAL PERSONNEL

January 2010

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NOTE This LES was designed within the framework of training sessions. It may require adaptation before being used with students.

Properties of solutions

Now a bit of math

Mathematical relations to be used for a **solid** solute.		
$C = \frac{M_{soluté}}{V_{solution}}$	$M_{soluté} = C \times V_{solution}$	$V_{Solution} = M_{solute}/C$

Mathematical relations to be used for a **liquid** solute.		
$C = \frac{V_{soluté}}{V_{solution}}$	$V_{soluté} = C \times V_{solution}$	$V_{Solution} = V_{solute}/C$

Question 1
What quantity of salt is necessary to the preparation of 1.18L of saline solution whose concentration is 22 % m/v?

$M_{soluté} = C \times V_{solution} = 259.6\ g$

Question 2
What volume of water (in mL) is necessary to the preparation of a sweet solution containing 253g of sugar and whose concentration is 22g/L?
$V_{Solution} = M_{solute}/C = 11\ 500\ mL$

Question 3
What is the concentration of a solution prepared using 325mg of solute and 250mL of solvent? Express the concentration in g/L and in % m/v.

$$C = \frac{M_{soluté}}{V_{solution}} = 1.3\ g/L = 0.013\%\ m/v$$

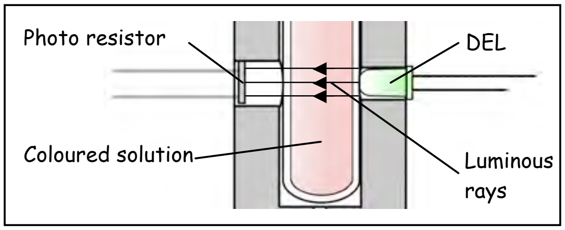
Question 4
What quantity of pure methanol is necessary to the preparation of 750mL of solution whose concentration is 35%v/v?
$V_{soluté} = C \times V_{solution} = 262.5\ mL$

Function of a colorimeter

Remarks:

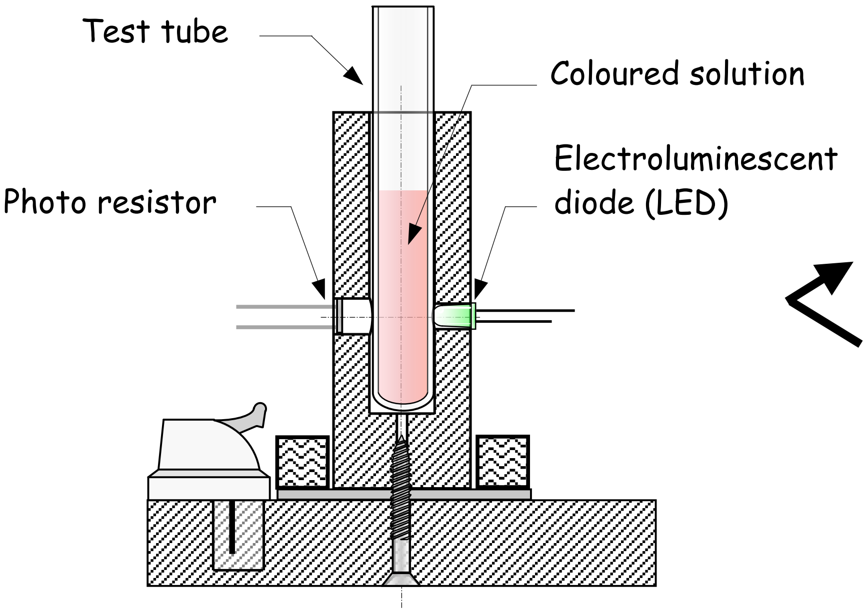
- ✓ Since we are using a green LED here, it would be preferable not to use this colorimeter with a green solution as well. As we know, a green substance absorbs all the colours except green, which it reflects. The basic principle of this colorimeter is precisely the absorption of light by the solution. The performance of the colorimeter would be uncertain in this case.

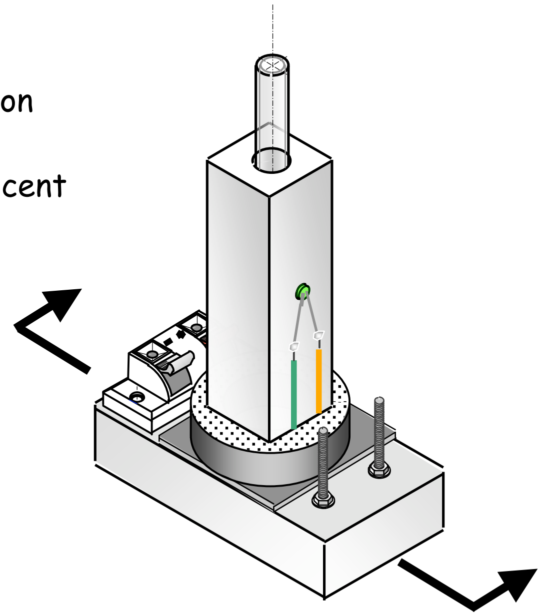
- ✓ The photo resistor is a resistor whose resistance varies according to the light that hits it. The luminous energy thus captured helps the electrons to propagate in the semi-conductor that makes up the photo resistor. You can see here what a coloured and concentrated solution implies regarding the electrical resistance read by an ohmmeter:



large concentration → dark hue → little light → **large resistance**

Cut view drawing of the colorimeter





Directed laboratory: Preparing a solution

Problem

Prepare 25 mL of solution having a concentration of 200 g/L using the solid solute. Validate the concentration of your solution using the colorimeter.

Calculation of the required quantity of solute

Data M_{solute} = ? g C = 200 g/L $V_{solution}$ = 25 mL	*Calculation(s)* $M_{solute} = 200\ g/L \cdot 25\ mL$ $M_{solute} = \frac{2\cancel{00}\ g}{\cancel{1L}} \cdot \frac{25\ \cancel{mL}}{1} \cdot \frac{\cancel{1L}}{10\cancel{00}\ \cancel{mL}}$ Answer: M_{solute} = 5 g
Equation(s) $M_{solute} = C \cdot V_{solution}$	

Calibrating the colorimeter

Important remarks

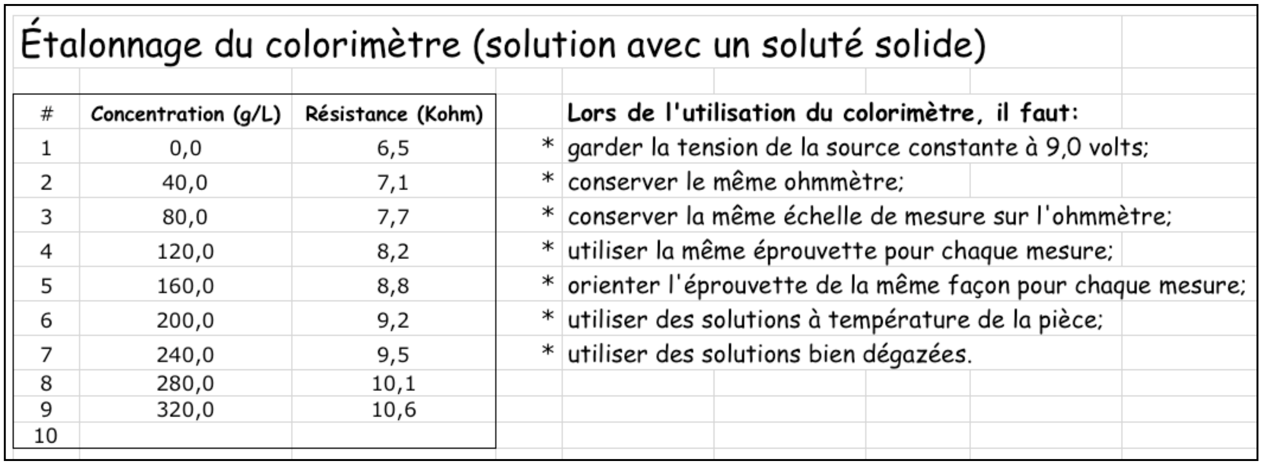
- ✓ The water that will be used during the preparation of the solution must have had to time to settle (degas) and to reach room temperature. If this is not the case, small air bubbles may be deposited on the walls of the test tube. These bubbles deflect the light emitted by the LED, which changes the light detected by the photo resistor. The use of distilled, room temperature water is recommenced.
- ✓ It is important to always use the same test tube with any given colorimeter. It is also important to always orient this test tube the same way while measuring. A mark to this effect must be made on the test tube.

Manipulations

1. Place the source of current under tension and adjust the tension to 9.0 V. (This tension should remain stable when using the colorimeter. An unstable tension will have an impact on the integrity of the measurements).
2. Connect the source of current to the LED (diode) of the colorimeter using alligator clip wires. (Since the current is unidirectional in an LED, it is important to respect the polarities).
3. Check that the LED is emitting light by looking inside the test tube holder.
4. Connect the multi meter to the terminals and select the resistance mode with a scale close to 200 KΩ. (Do not change the multi meter or its scale while using the colorimeter, otherwise the measurements will not be exact).
5. Check that the colorimeter is working by observing whether the measurement shown by the multi meter changes when you hide the end of the test tube holder with your finger. (Preventing the ambient light from entering the tube should increase the resistance measured.)
6. Prepare approximately 10 solutions having hues (concentrations) between that of distilled water and a saturated solution, inclusively.
7. Measure and note the electrical resistance corresponding to each of the given concentrations of your prepared solutions.
8. Draw a calibration graph of concentration versus electrical resistance. (See the following page for an example).

Important remarks concerning the graph

- ✓ Each colorimeter must have its own calibration graph. Indeed, the electrical characteristics of photo resistors are never identical.
- ✓ The calibration graph may be hand made, but the use of "Excel" makes the work much easier. In fact, this software will create the tendency curve itself and give the equation of the function. Two excel worksheets are available on the CDP website. In one, the concentration is indicated in %v/v (for liquid solutes) and in the other, the concentration is expressed in g/L (for solid solutes).
- ✓ The graph thus drawn is in the second degree (parabola) and comes from the electrical characteristics of the photo resistor. <u>The notion of the parabola should not be addressed with the students.</u> The student simply uses the curve to make a given resistance correspond to a concentration.
- ✓ For adequate precision, a large number of measurements (around 10 measurements) is necessary to tracing the parabola.

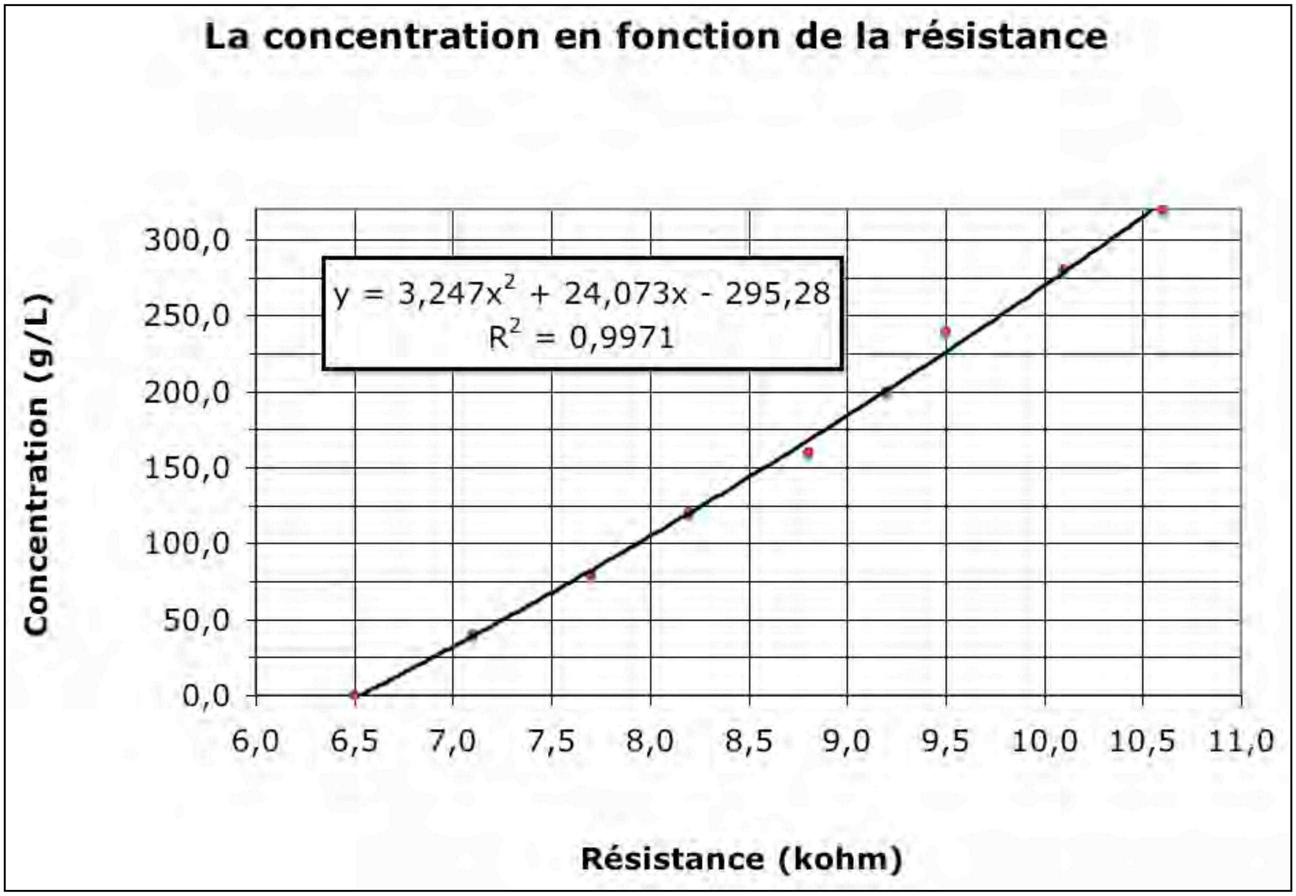


Étalonnage du colorimètre (solution avec un soluté solide)

#	Concentration (g/L)	Résistance (Kohm)
1	0,0	6,5
2	40,0	7,1
3	80,0	7,7
4	120,0	8,2
5	160,0	8,8
6	200,0	9,2
7	240,0	9,5
8	280,0	10,1
9	320,0	10,6
10		

Lors de l'utilisation du colorimètre, il faut:

* garder la tension de la source constante à 9,0 volts;
* conserver le même ohmmètre;
* conserver la même échelle de mesure sur l'ohmmètre;
* utiliser la même éprouvette pour chaque mesure;
* orienter l'éprouvette de la même façon pour chaque mesure;
* utiliser des solutions à température de la pièce;
* utiliser des solutions bien dégazées.



Directed laboratory: Analyse the results

Question 1

Is the concentration found during validation similar to that which was required in the problem? *« This should be the case! »*

Question 2

Name the sources of imprecision related to manipulations carried out during the preparation of the solution.

The precision of the scale and gauged balloon, the loss of grains of solute and splashing could also be causes for error.

Question 3

Name the sources of imprecision related to the function of the colorimeter.

The precision of the source of current and of the multi meter, an imprecise calibration as well as the presence of bubbles of air are all causes for error.

Non ferrous alloy: « nitinol »

Remarks

- ✓ You can buy nitinol springs on the Internet at the following address: http://www.mondotronics.com/nitinolsprings.shtml
  This is a set of four tension springs (number 3-642). The cost of the four springs is around $55 CDN including shipping. Since we cut the springs in half during the activity, the cost per spring is $6.88 ($55/8).
- ✓ Do not heat the nitinol too much since you could bring it up to a temperature where it would lose its memory (in the order of 500° Celsius). The source of current used should therefore not be too powerful. A current of about 2.5 A is entirely appropriate. The reaction time of the nitinol will not be lightning fast but you can be sure you won't damage the spring. In an environment where the temperature is lower than a normal room temperature (≈20 °C), a stronger current would be necessary.

Questionnaire about nitinol

Question 1
From which metals is nitinol made?
Nickel and titanium

Question 2
Name the five states possible for nitinol.
Gaseous, liquid, solid (martensite, distorted martensite and austenite)

Question 3
Under what conditions is nitinol malleable and ductile?
When it is in the martensite state, whether or not it is distorted.

Question 4
Name three ways in which nitinol takes on a pre-defined shape.
It must be heated: plunging it in hot water, with hot air or using the joule effect.

Question 5
What critical temperature would you choose if you were using nitinol to make a frame for glasses (-10°C, 37°C or 50°C)? **Why?**
A critical temperature of -10 °C would be perfect since the nitinol would constantly be in its austenite state and would always regain its shape.

Question 6
What critical temperature would you choose if you were using nitinol to make an artery dilator (-10°C, 37°C or 50°C)? **Why?**
A critical temperature of 37 °C would be perfect since the nitinol could take a predetermined shape upon contact with blood.

Question 7
What critical temperature would you choose if you were using nitinol so that it contracts using an electrical current (-10°C, 37°C or 50°C)?
A critical temperature of 50 °C would be perfect since an electrical current can easily produce such a temperature elevation and generate the return to a predetermined shape. With the temperature at 37 °C a simple contact with a hand could provoke a state change. Have you ever heard of the magic spoon[1] that twists with the power of the mind?

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[1] http://charlatans.info/pouvpar.shtml

Preparing the antiseptic solution

Important remarks concerning colouring alcohol

We must use colouring in order to be able to use the colorimeter as a validation instrument for the concentrations. Here are some remarks that seem important to us:

- ✓ Since we will be using a green LED, it is preferable not to use this colorimeter with a green coloured solution.
- ✓ We suggest you colour the alcohol and not the distilled water. This way, the more the solution is concentrated, the darker it will be. Pedagogically, this seems a judicious choice.
- ✓ The quantity of colouring to be added to the alcohol is not always simple to determine. It depends on the type of colouring used. You must not put too much colouring, otherwise the solution will remain strongly coloured when the solvent is added. Conversely, too pale a solution does not allow the colorimeter to be used to its full potential. You will doubtless have to make several tries.
- ✓ It is important to stir the colouring before each use. In that way, you will be able to predict the ideal quantity of colouring to add in relation to your tests. Without stirring, you will be riding blind.

Question: **How do we prepare 25mL of a solution with a concentration identical to commercial antiseptic solutions (62% v/v) beginning with 100% v/v alcohol?**

Calculation of the necessary quantity of solute

Data	*Calculation(s)*
V_{solute} = ? mL C = 62 % V/V $V_{solution}$ = 25 mL	$V_{solute} = 62\ \%\ V/V \cdot 25\ \text{mL}$ $V_{solute} = \frac{62\ \text{mL}}{100\ \cancel{\text{mL}}} \cdot \frac{25\ \cancel{\text{mL}}}{1}$ Answer: V_{solute} = 15,5 mL
Equation(s) $V_{solute} = C \cdot V_{solution}$	

Example of manipulations

Preparing the solution

1. Calculate the volume of solute (pure alcohol) necessary.
2. Measure 15.5 mL of alcohol, using a graduated cylinder.
3. Transfer the alcohol into the 25 mL gauged balloon.
4. Pour about 5 mL of distilled water into the graduated cylinder in order to recover the alcohol left on the walls.
5. Transfer the contents of the graduated cylinder into the gauged balloon.
6. Complete the volume, coming close to the mark by adding distilled water with the wash bottle.
7. Shake the balloon in order to distribute the alcohol well in the solution.
8. Complete the precise volume right to the mark (watch the bottom of the meniscus) adding distilled water with the eye-dropper.
9. Shake again and proceed to the validation of the concentration using the colorimeter.

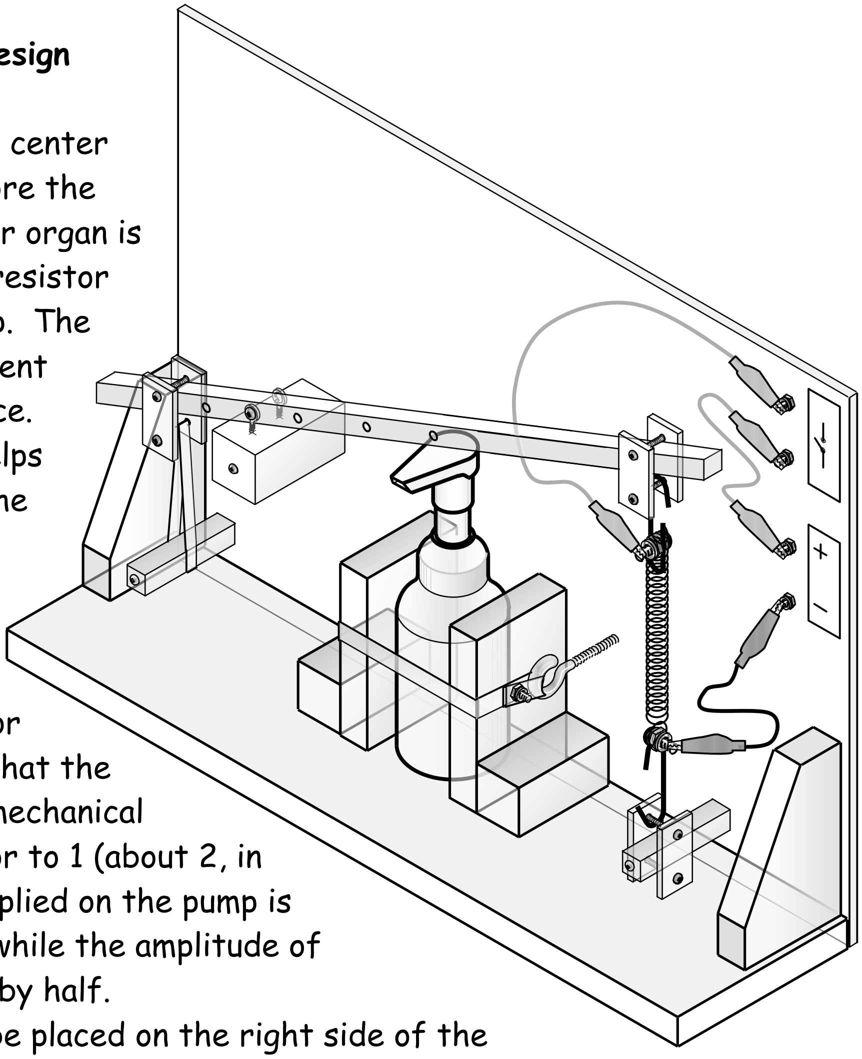
Question: **How do we validate the concentration obtained to ensure the efficacy of the solution?**

Example of manipulations

Validating the concentration

1. Transfer about 15 mL of your solution in a 50 mL beaker.
2. Go to the validation station with your sample (50mL beaker).
3. Withdraw the dark room from the colorimeter.
4. Withdraw the test tube from the colorimeter.
5. If the test tube is clean and dry, transfer your sample into it.
   Careful: A wet or dirty test tube must first be rinsed with a part of your solution.
6. Place the test tube inside the colorimeter, orienting it according to the marks.
7. Place the dark room onto the colorimeter in such a way as to completely prevent the ambient light from lighting the sample.
8. Read and note the resistance indicated by the multi meter in the data table.
9. Consult the calibration graph and note the resistance in order to validate your work.

Example of a design solution for a dispenser



Remarks concerning the design

- ✓ The lever used here is a center load (class 2) lever (ignore the elastic band). The motor organ is the nitinol spring. The resistor organ is the bottle pump. The elastic band is only present to apply a restoring force. This restoring force helps the pump to return to the top and stretches the nitinol spring when it is at a low temperature. The motor length[2] is greater that the resistor length[3]. The effect is that the mechanical advantage (mechanical gain) obtained is superior to 1 (about 2, in our case). The force applied on the pump is thus multiplied by two, while the amplitude of movement is decreased by half.
- ✓ The elastic band could be placed on the right side of the support, pulling upwards.
- ✓ A center pivot (class 1) lever could also be used, by placing the nitinol spring on the other side of the pivot. In that case, the nitinol spring would have to pull upwards. You must ensure that the mechanical advantage is greater than 1 (increasing the force).
- ✓ A center force (class 3) lever does not constitute a good solution, since this type of lever always has a mechanical advantage inferior to 1.

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[2] Length measured between the pivot and the motor.

[3] Length measured between the pivot and the resistor organ.

Interesting websites

National Research Council of Canada

Teacher's corner: Life science

http://www.nrc-cnrc.gc.ca/eng/education/teachers/life/index.html

Evaluation of antiseptic solutions (CBC)

http://cosmos.bcst.yahoo.com/up/player/popup/index.php?rn=222561&cl=16939515&ch=

http://www.cbc.ca/video/news/player.html?clipid=1347810814