Activity: Reusable versus Consumable ECG Electrodes

Materials and Tools

• 1 roll medical tape  • 3 hand sanitizer packets  • 2 sewing snaps 	• 2 alligator to alligator leads  • 2 disposable electrodes  • 1 multimeter 

Digital Multimeter

Today we are going to do some biomedical engineering activities, but before we start the experiments, let's learn first about a tool we will need to use.

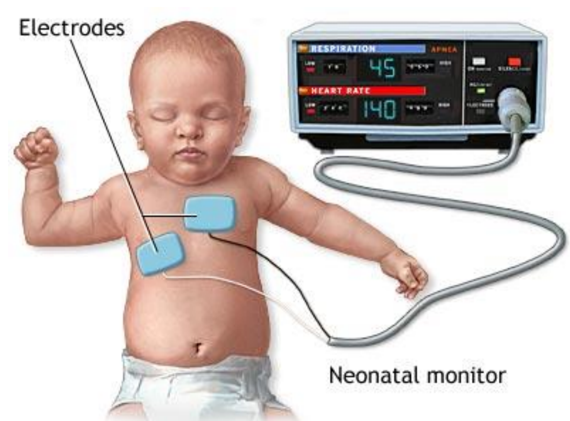
A **multimeter** measures voltage, current, resistance, and temperature. The dial on the device allows you to choose the function you are interested in reading, and it also determines the range of measurement. Changing this range moves the placement of the decimal point in the display, allowing you to measure very high or very low values with the same multimeter.

OR*

*If you are using an Engineering World Health Kit you will receive one of these two multimeters.

Introduction

Electrodes (also called pads) are used to measure electrical signals within the body as well as stimulate muscles. Therefore, we can consider them electrical conductors with very small resistence. The figure to the right shows a neonatal monitor that reads the baby's heart and breath rate.



Although these electrodes are relatively inexpensive (around $0.25 each), hospitals can use 100-500 a day. They can become very expensive for medical institutions in resource-poor areas. Do the math: what is .25 x 500? Now multiply that by 365 days a year.
Write your answer below.

This may not seem like much, but here's a chart to put the cost into a hospital administrator's perspective.

Machine	Cost
Implantable Pacemaker	$4,020.00
Prosthetic Heart Valve	$5,142.00
Anesthesia Unit	$42,251.00
Electric Bed	$13,107.00
Portable Ultrasound	$38,449.00
Stretchers	$5,517.00
ESU (electrosurgical unit)	$15,770.00

All of the machines listed above cost less than the price of a year's worth of disposable electrodes. They are all vital elements of optimal patient care. By replacing disposable electrodes with reusable electrodes, similar to the ones you are making today, a hospital could save enough money to buy some other necessity, perhaps another bed or tools for surgery.

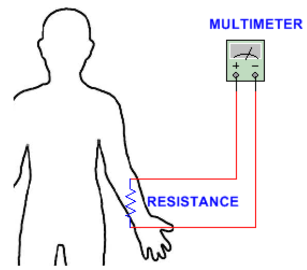
You will make a low-cost electrode designed by Engineering World Health, the kind of electrode that would be more cost-effective in areas of the world where every penny counts!

Activity Details: Use these materials to create and test homemade electrodes.

Test Process: The electrodes you build will be tested by using the multimeter in the resistance measurement position. You will also compare the performance with commercial pads.

Building Low Cost Reusable Electrodes

We are now ready to measure the electrical resistance of the wrist. The human skin can work as a conductor, just like electrical wires. However, the skin's electrical resistance/conductivity can change under varying parameters. For example, the moisture level of the skin will impact how well or how poorly it resists electricity. We will measure the body's resistance on an area of approximately three inches on our wrist. Set the multimeter to 2000kΩ to measure resistance.



Use the photos below as a guide. You will need a partner to help you with the measurements. Also, be aware that the measurements may vary somewhat. To be consistent, record each resistance value at about five seconds after you connect the leads to the electrodes.

First, take measurements of your wrist resistance without the electrodes, as seen in the photo below. Simply lay the multimeter leads on the underside of your arm near your wrist. Be careful not to touch the metal part of the leads with the fingers, because we want to measure only the resistance of the skin on your wrist, not the skin on your fingers.

Wrist resistance: ______________ MΩ
(no electrodes)

Now let's make some low-cost electrodes; here are the steps:

Cut a small hole in the center of a piece of adhesive tape. Place a sewing snap on the underside of your arm, about half way between your wrist and elbow. Tape the snap on your skin with the snap emerging through the hole in the tape. Add another sewing snap electrode to your wrist about three inches from the first one.	

The snaps will function as our electrodes! They are cheap, reusable and can be disinfected before use on a new patient.

Measure your skin resistance using the snaps in place of commercial electrodes. You can do so by attaching the multimeter leads, one to each snap.

Wrist resistance: ______________ KΩ
(EWH electrodes - dry)

Now wipe the bottom of each snap with a hand sanitizer wipe where it touches the skin and repeat the measurement. The hand sanitizer wipe mimics commercial electrode gel.

Wrist resistance: ______________ KΩ
(EWH electrodes - wet)

Now measure your wrist resistance using commercial electrodes such as the one on the right. These pads have a conducting gel in them already, so the skin gets wet and the resistance decreases.

Wrist resistance: ______________ KΩ
(Commercial disposable electrodes)

Fill in the table below with the data from each of your measurements and compare them.

Description	Resistance (KΩ)
No electrodes/pads (dry)	
Reusable snap/electrode dry	
Reusable snap/electrode wet	
Disposable commercial electrodes	

The lower the skin resistance, the better the electrode quality. The better the electrode quality, the better the information the medical care provider receives from the electrode. Since doctors make decisions based on information they receive from these electrodes, better electrodes offer better information, which means better care for the patient. Complete this table, in order from the lowest to the highest resistance:

Lowest resistance rank	Measurement description
1	(BEST technique)
2	
3	
4	(WORST technique)

Are the results with the low-cost electrode and the disposable electrode similar? If so, then is the low-cost electrode a viable replacement for a disposable commercial electrode?

Can the low-cost electrode be improved? What are some ways it could be better?

Did the hand sanitizer lower the resistance? Why?

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