Knowledge Domain: Electrical Simple
Unit: Fabrication
Skill: ECG Cables

Tools and Parts Required:

1) **ECG machine with 3 leads**
2) **1.8 meter of copper electrical wires, 16-gauge stranded (x5)**
3) **40mm of solid copper core conductor wires, 22-gauge (x5)**
4) **Fully insulated alligator clips (x5)**
5) **Waterproof silicone gel**
6) **20mm long piece of PVC tubing, 2 cm in diameter**
7) **1 kΩ resistors (x6)**
8) **Soldering iron**
9) **Solder**
10) **Sponge**
11) **Heat shrink tubing**
12) **Velcro strips**
13) **Electrical tape**
14) **Scotch tape**
15) **Electrician wire scissors**
16) **Marker**
17) **Hot air gun or lighter**

Introduction

Sometimes donated equipment or purchased equipment can get separated from its cables. This skill teaches you how to build a replacement cable. These instructions are for cables used for electrocardiography (ECG).

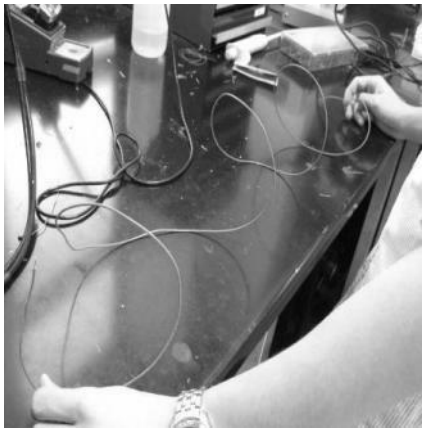
Identification and Diagnosis

If a medical device is not working, the connecting cables should be checked. There may be a frayed or torn cable. The connector may not connect at the pin site (jack). Use the BTA skill *Electrical-Connectors-Loose Connectors* or *Electrical-Connectors-Replacing Connector Pins* to repair connections. Repair or replace broken cables. Fabricate a cable only if you are not able to repair or find the original cable.

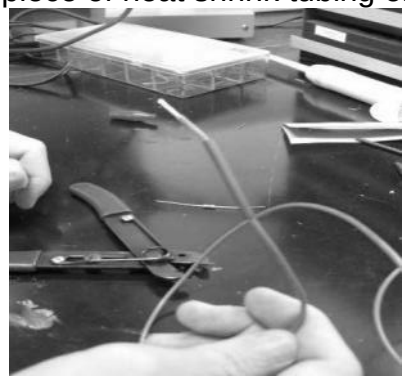
Procedure

Part 1

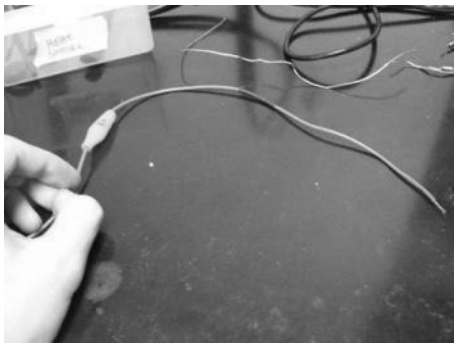
1. Cut five 1.8 meter long segments of electrical wire.



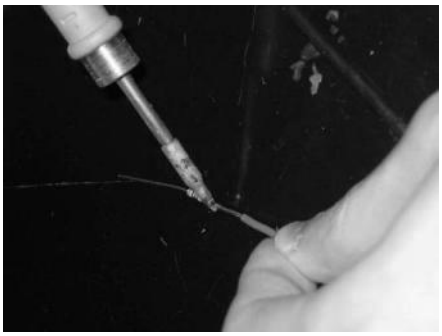
2. These wires will become the main cables of each lead. Strip both ends of each wire, and fit a piece of heat shrink tubing onto the wire.



3. Slide an alligator clip insulator onto the wire.

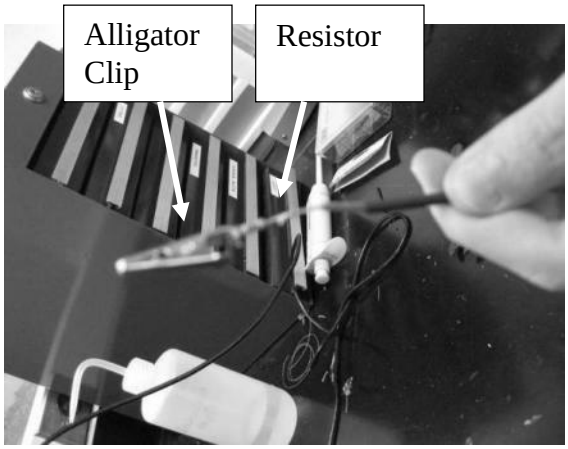


4. Solder a 1000 Ω resistor to each wire.



Part 2

1. Solder alligator clips to the ends of each resistor.

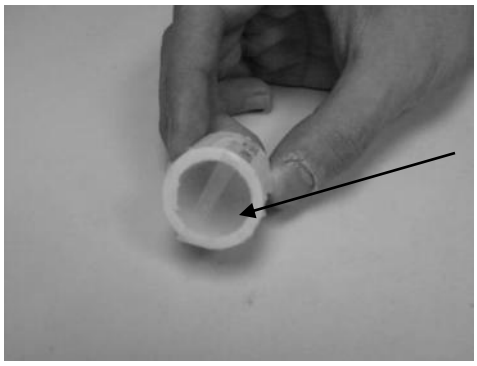


2. Slide the heat shrink over the resistor connections and heat with hot air gun (or lighter if you do not have a hot air gun). Then fit the alligator clip wrap over the clip.

Repeat the above steps for each lead, to produce five wires total.

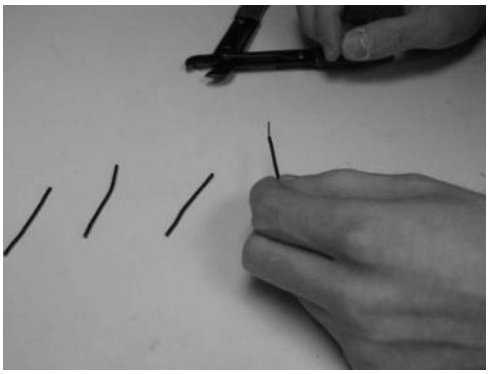
Part 3

1. Construct the plug mold by using a saw or sharp cutting tool to cut a 20 mm length segment of PVC pipe. Completely cover one end of the PVC cylinder with clear tape.



Clear tape on one end

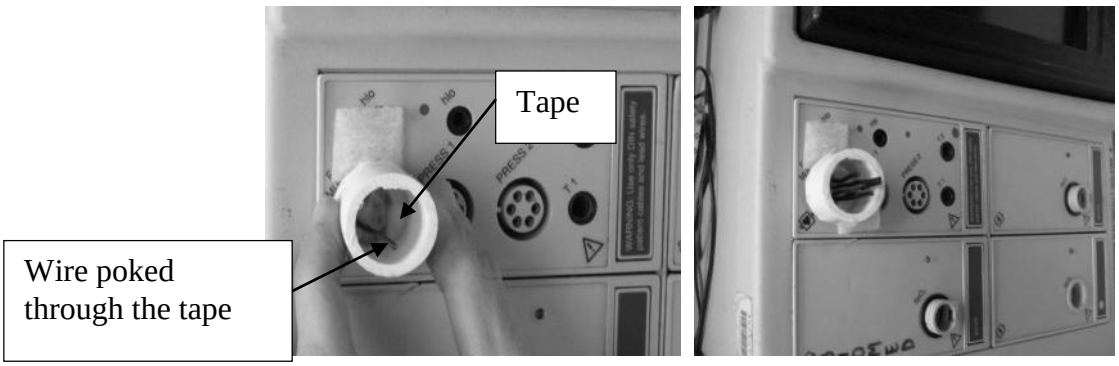
2. Make a new pin by cutting about 40 mm of solid core copper conductor wire. Strip both ends of your new solid core wires. Make as many pins as your machine has sockets.



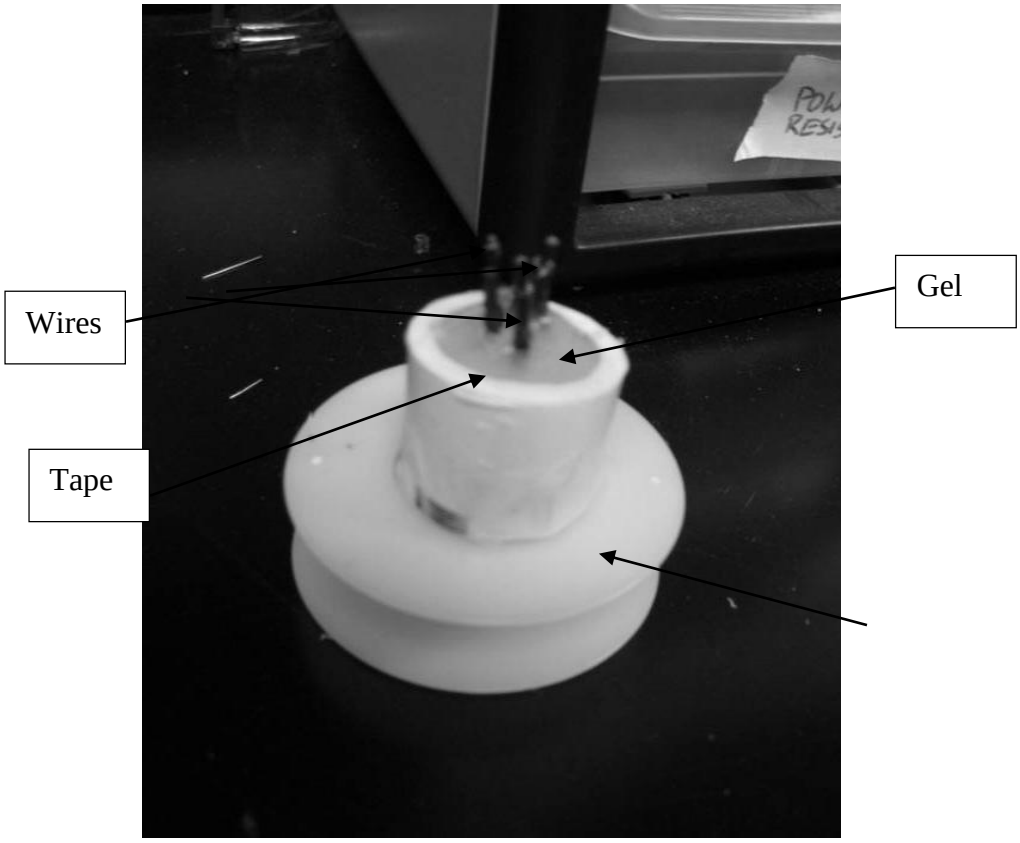
Pieces of solid core copper wire stripped on one end

3. Hold the tube over the connection on the machine with the tape side touching the machine. Make a mark on the PVC plug to indicate the proper orientation of the plug. You can attach Velcro pads to the plug and the cable port on the device as demonstrated in the figure below. The Velcro pads will hold the PVC tube in place.

4. Poke the stripped end of the solid core wires through the tape matching the holes of the desired connection receptor. Alternatively, use a pencil to make the holes, and then insert the wires.



5. Fill the PVC tubing with silicone gel squeezed from the tube. Use a spool to support the PVC tubing as it dries (see picture below). It should allow the PVC plug to sit securely without the wires touching the surface below. Let the gel set for about an hour, then remove the tape. Allow the silicone gel to dry overnight.

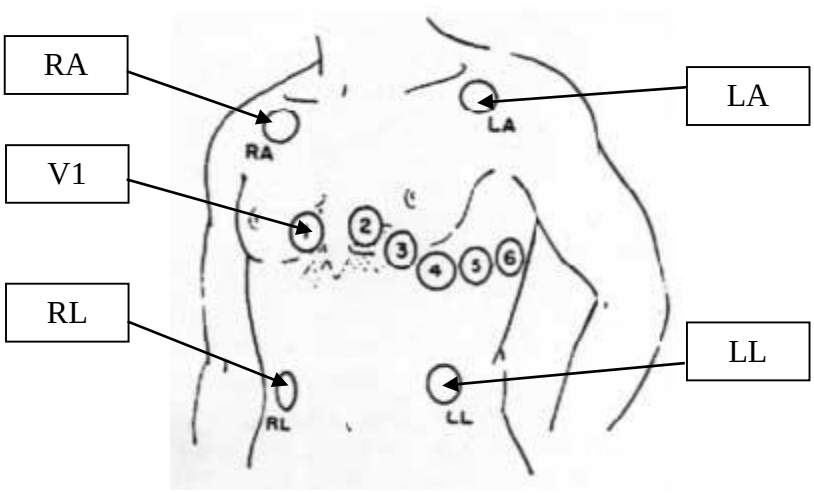


7. Insert the cable housing into the device according to its proper orientation. Insure the fit is accurate.

Part 4

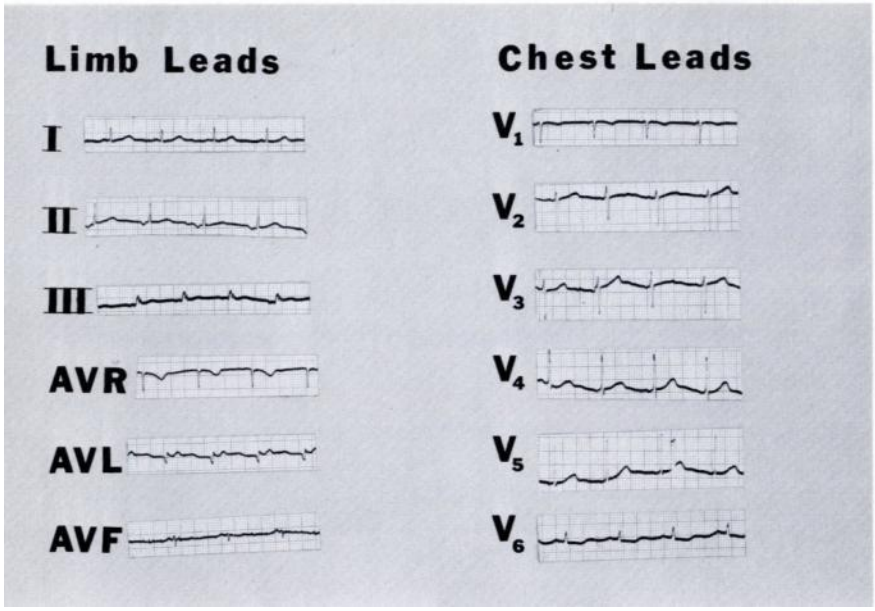
If the cable is lost, you must determine the proper pin layout of the ECG machine using the following algorithm (for 3-lead machines):

1. Find lead I:
    a. Set the ECG to display Lead I.
    b. Connect ECG pads to the LA, RA, and RL positions as shown in the figure below. Connect any three clips to the ECG pads.
    c. Connect the wire ends of the clips to the sockets.
        i. First insert the plug you made in the previous step into the machine. Insure it is secure and correctly oriented.
        ii. Using additional alligator clips, attach the bare ends of the wires to the pins sticking out of your plug. Do not solder these in place.
        iii. Each wire on your plug corresponds to a socket. The following algorithm will deduce which signal goes with which socket.
        iv.



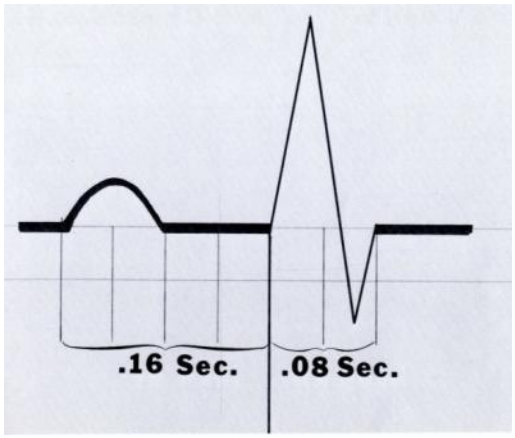
d. If you don't get a signal, try a new combination of three sockets. Keep trying new combinations of three sockets until there is an ECG signal. Do not worry if the machine is noisy.
e. When you get an ECG signal, you have identified the + and- pins of an ECG lead. But which is which? However, the signal may still be inverted.

The correct signals for the various leads will look like this:

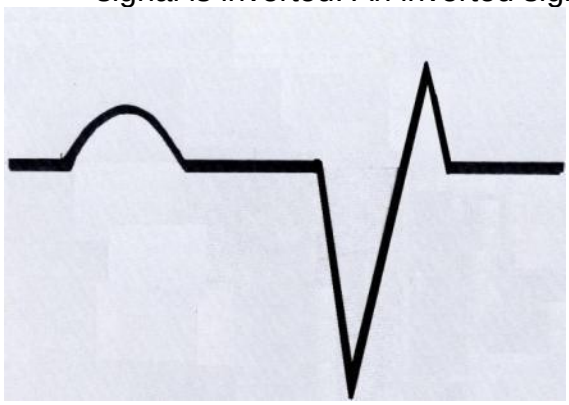


We focus on Leads I, II, III, and V1 in this skill.

An upright (correct) signal generally looks like this:



An “inverted signal” means that one of the main peaks of the signal is inverted. An inverted signal generally looks like this:



If your signal is inverted, rearrange the wires so that you get an upright (not inverted) Lead I recording using only the three sockets you have identified that give signals.

f. Record the sockets that correspond to LA and RA on a piece of paper.

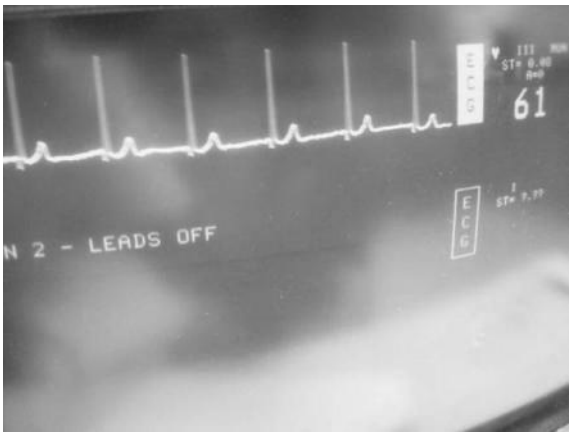
2. Find lead II:
    a. Set the machine to display Lead II.
    b. Attach an additional ECG pad to yourself in the LL position as shown in the figure above. Keep the LA and RA wires where they are (connected to your body LA and RA and connected to the LA and RA sockets on the machine).
    c. Connect a new wire to the new LL ECG pad. Try connecting to different sockets until an upright ECG Lead II signal is found.
    d. Record this socket location as the Left Leg (LL).
3. Find RL
    a. Attach one ECG pad to yourself in the correct location for the right leg. Keep the LA, RA and LL where they are.
    b. Connect a new wire to the new ECG pad. Clip the other end to any open socket in the machine. Move the wire until you find

the minimum possible noise in the signal. This is most likely the RL socket.

c. Record this socket location as the RL.

4. Find V1:
    a. Attach one ECG pad to yourself in the correct location for the V1 electrode. Keep the LA, RA, LL and RL where they are.
    b. Connect a new wire to the new ECG pad. Clip the other end to any open socket in the machine. Move the wire until you find a correct lead V1 recording.
    c. Record this socket location as V1.
5. Remaining sockets
    a. There may be one or more remaining sockets. Do not connect the remaining clips
    b. Connect the remaining wire to each of the remaining sockets. Move the wire until you see the signal that has the lowest noise. This probably the ground. Record this socket location as the ground. This connection should not be made to the patient. You can remove the clip, if you like.

The final, correct configuration should produce signal for various lead I, II, III configurations. It may be helpful to use pieces of tape to label which wires correspond to which locations. Change the settings on your ECG machine to make sure all leads work correctly.

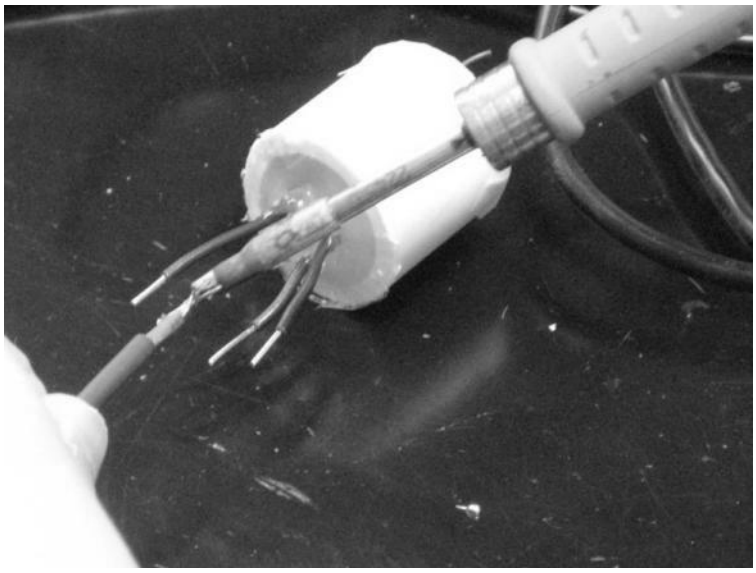


Part 5: Finishing

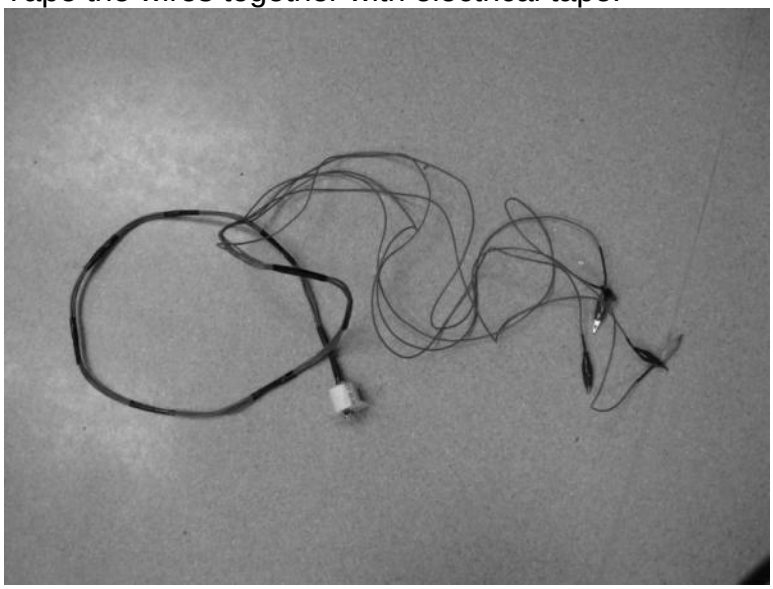
1. Slide the heat shrink on the end of each cable and solder the wires to the conductors embedded in the new connector plug in the appropriate positions as determined in step 3.

    -Test each connection for continuity using a digital multimeter.

    -Use a hot air gun or lighter to shrink the plastic and fit the plastic onto the soldered connection.



Tape the wires together with electrical tape.



Finished cables

Exercise

Your instructor will provide the necessary wires and material to create your own cables.

Preventative Maintenance and Calibration

Limitations:

> This cable is unique: once the cable is tailored to a particular machine, is not guaranteed to be suitable for another model. That is, once the cable housing is molded with its specific pin configuration, it will only work with that device.

Insure that the proper orientation of the plug is marked. The cable will produce incorrect signals if the plug is rotated.

Always calibrate every medical device before returning it to use.