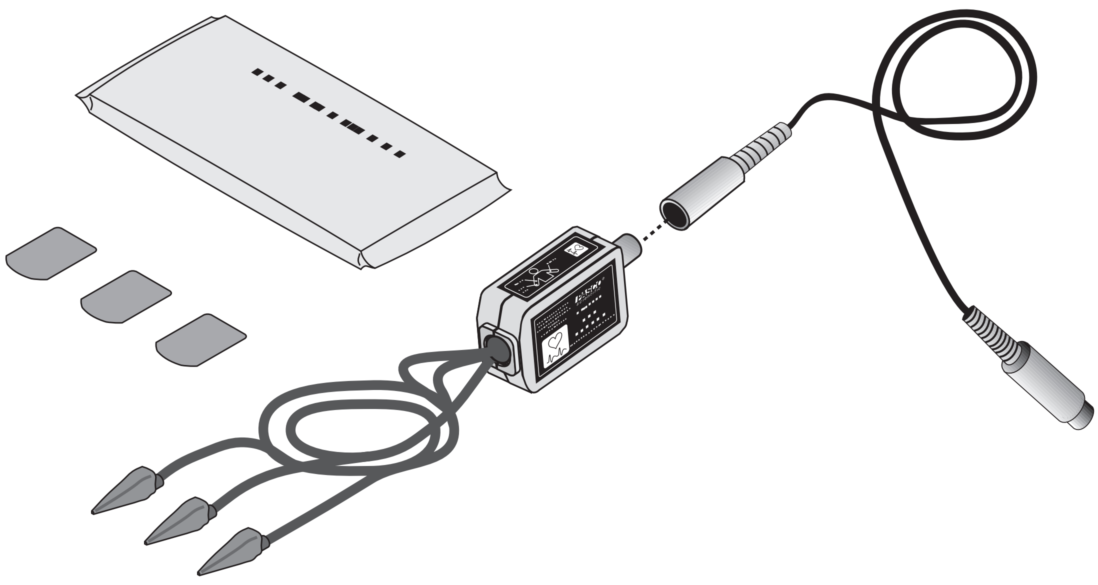
Includes Teacher's Notes and Typical Experiment Results

Instruction Manual and Experiment Guide for the PASCO scientific Model CI-6539A

012-06852A

11/98

EKG SENSOR



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Copyright, Warranty, and Equipment Return

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PASCO scientific warrants the product to be free from defects in materials and workmanship for a period of one year from the date of shipment to the customer. PASCO will repair or replace at its option any part of the product which is deemed to be defective in material or workmanship. The warranty does not cover damage to the product caused by abuse or improper use. Determination of whether a product failure is the result of a manufacturing defect or improper use by the customer shall be made solely by PASCO scientific. Responsibility for the return of equipment for warranty repair belongs to the customer. Equipment must be properly packed to prevent damage and shipped postage or freight prepaid. (Damage caused by improper packing of the equipment for return shipment will not be covered by the warranty.) Shipping costs for returning the equipment after repair will be paid by PASCO scientific.

Credits

Author: Larry Fulton

Equipment Return

Should the product have to be returned to PASCO scientific for any reason, notify PASCO scientific by letter, phone, or fax BEFORE returning the product. Upon notification, the return authorization and shipping instructions will be promptly issued.

➤ **NOTE:** NO EQUIPMENT WILL BE ACCEPTED FOR RETURN WITHOUT AN AUTHORIZATION FROM PASCO.

When returning equipment for repair, the units must be packed properly. Carriers will not accept responsibility for damage caused by improper packing. To be certain the unit will not be damaged in shipment, observe the following rules:

① The packing carton must be strong enough for the item shipped.

② Make certain there are at least two inches of packing material between any point on the apparatus and the inside walls of the carton.

③ Make certain that the packing material cannot shift in the box or become compressed, allowing the instrument come in contact with the packing carton.

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Introduction

The PASCO CI-6539A EKG (Electrocardiogram) Sensor measures cardiac electrical potential wave forms (voltages produced by the heart as its chambers contract). The sensor is designed for use with a PASCO computer interface as an educational aid; it is not intended for medical diagnosis.

This sensor complements the PASCO CI-6535 Respiration Rate Sensor.

The sensor consists of the electronics box with a cable for connecting to the PASCO computer interface via a five pin DIN analog connector. Three electrode leads enter the electronics box on the side opposite the cable that attaches to the interface. The sensor's circuitry isolates the user from the possibility of electrical shock in two ways.

- The sensor signal is transmitted through an opto-isolation circuit.
- Power for the sensor is transferred through an isolation transformer.

The circuitry protects against accidental overvoltages of up to 4,000 volts.

The sensor comes with a package of one hundred silver/silver chloride electrode patches that can be attached to the skin.

Equipment

Included:

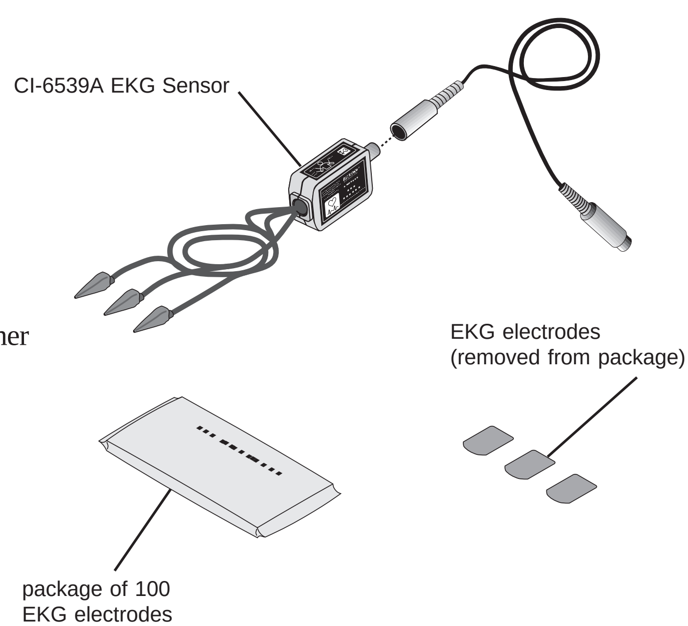
- EKG Sensor unit
- package of 100 EKG electrodes

Additional Required:

- computer (PC or Macintosh)
- *Science Workshop*® computer interface
- *Science Workshop*® software version 2.2 or higher

Replacement Parts:

Item	**PartNumber**
EKG electrodes (100)	CI-6620



Theory

Heart muscle cells are polarized at rest. This means the cells have slightly unequal concentrations of ions across their cell membranes. See Figure 1. An excess of positive sodium ions on the outside of the membrane causes the outside of the membrane to have a positive charge relative to the inside of the membrane. The inside of the cell is at a potential that is about 90 millivolts (mV) less than the outside of the cell membrane. The 90 mV difference is called the **resting potential.** See Figure 1.

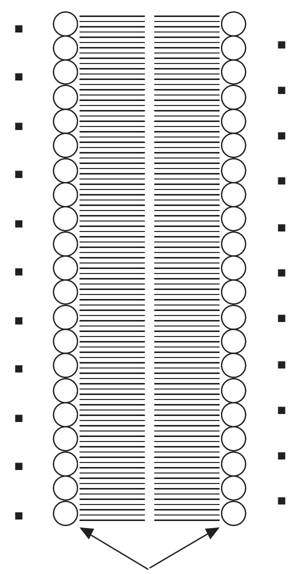


Figure 1
Animal Cell Membrane (sectional view)

The typical cell membrane is relatively impermeable to the entry of sodium. However, the stimulation of a muscle cell causes an increase in its permeability to sodium. Some sodium ions migrate into the cell. This causes a change (depolarization) in the electrical field around the cell. This change in cell potential from negative to positive and back is a voltage pulse called the **action potential**. In muscle cells the action potential causes a muscle contraction. Other ions and charged molecules are involved in the depolarization and the recovery back to the polarized state. These include potassium, calcium, chlorine and charged protein molecules. The effect of this depolarization and repolarization for the entire heart can be measured on the skin surface. This is an electrocardiogram (EKG). The depolarization of the heart also leads to the contraction of the heart muscles and therefore the EKG is also an indicator of heart muscle contraction (although this is an indirect measurement).

The cells of the heart will depolarize without an outside stimulus; that is, they will depolarize spontaneously. The group of cells that depolarize the fastest is called the **pacemaker** (also known as the *sinoatrial* or **SA node**). These cell are located in the **right atrium**. The cells of the atria are all connected physically and thus the depolarization of the cells of the pacemaker cause all the cells of both atria to depolarize and contract almost simultaneously.

The atria and the ventricles are isolated from each other electrically by connective tissue that acts like the insulation on an electric wire. The depolarization of the atria does not directly affect the ventricles. There is another group of cells in the right atria, called the *atrioventricular* or **AV node**, that will conduct the depolarization of the atria down a special bundle of conducting fibers (called the **Bundle of His**) to the ventricles. In the muscle wall of the ventricles are the **Purkinje fibers**, which are a special system of muscle fibers that bring depolarization to all parts of the ventricles almost simultaneously. This process causes a small time delay and so there is a short pause after the atria contract before the ventricles contract. Because the cells of the heart muscle are interconnected, this wave of depolarization, contraction and repolarization spreads across all the connected muscle of the heart. See Figure 2.

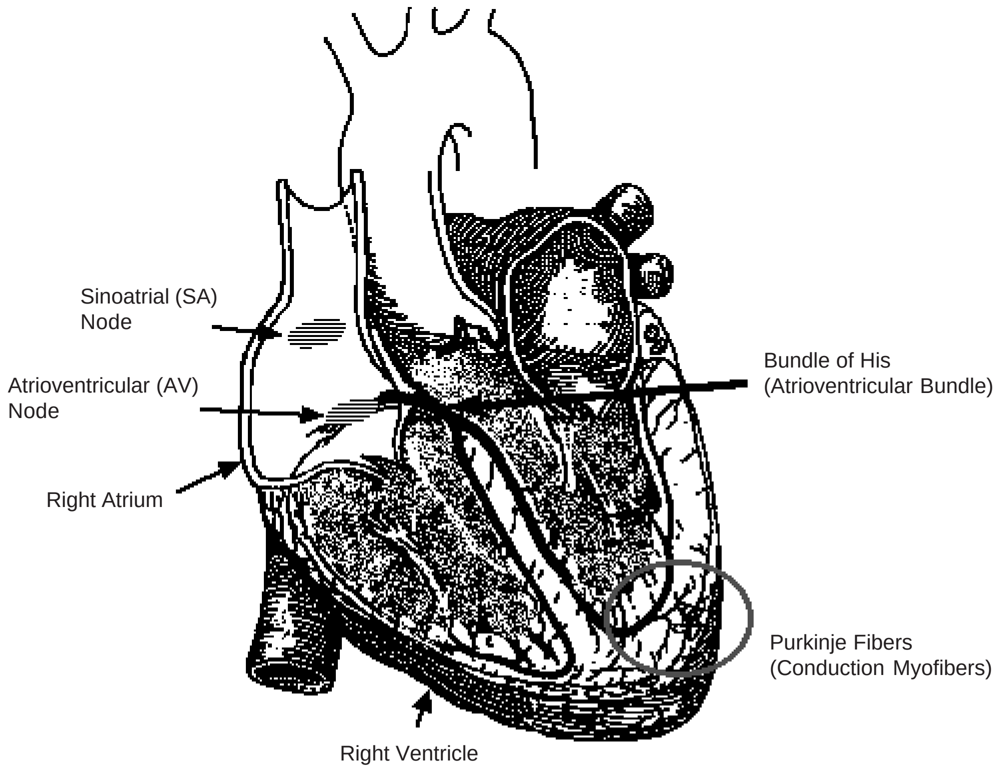


Figure 2
Cross section of human heart

When a portion of the heart is polarized and the adjacent portion is depolarized this creates an electrical current that moves through the body. This current is greatest when one half of the connected portion of the heart is polarized and the adjacent half is not polarized. The current decreases when the ratio of polarized tissue to non-polarized tissue is less than one-to-one. The changes in these currents can be measured, amplified, and plotted over time. The EKG represents the summation of all the actions potentials from the heart as detected on the surface of the body and does not measure the mechanical contractions of the heart directly.

The two atria contract due to the pacemaker and force blood into the two ventricles. Shortly after this contraction the two ventricles contract due to the signal conducted to them from the atria. The blood leaves the two ventricles through pulmonary and aortic arteries. The heart muscle cells recover their polarity and in another second the cycle starts again.

➤ **Note:** An excellent text about the electrocardiogram and other phenomena of bioelectricity is *Physics with Health Science Applications* by Paul Peter Urone, ©1986, John Wiley & Sons, Inc., New York.

The Electrocardiogram

One part of a typical EKG (electrocardiogram) is a ‘flat line’ or trace indicating no detectable electrical activity. This line is called the **Isoelectric line**. Deviation from this line indicates electrical activity of the heart muscles.

The first deviation from the Isoelectric line in a typical EKG is an upward pulse followed by a return to the Isoelectric line. This is called the **P wave** and it lasts about 0.04 seconds. This wave is caused by the depolarization of the atria and is associated with the contraction of the atria.

After a return to the Isoelectric line there is a short delay while the heart’s **AV node** depolarizes and sends a signal along the atrioventricular bundle of conducting fibers (**Bundle of His**) to the **Purkinje fibers**, which bring depolarization to all parts of the ventricles almost simultaneously.

After the AV node depolarizes there is a downward pulse called the **Q wave**. Shortly after the Q wave there is a rapid upswing of the line called the **R wave** followed by a strong downswing of the line called the **S wave** and then a return to the Isoelectric line. These three waves together are called the **QRS complex**. This complex is caused by the depolarization of the ventricles and is associated the with the contraction of the ventricles.

After a short period of time the sodium and calcium ions that have been involved in the contraction migrate back to their original location in a process that involves potassium ions and the **sodium-potassium pump**. The movement of these ions generates an upward wave that then returns to the Isoelectric line. This upward pulse is called the **T wave** and indicates repolarization of the ventricles. The atria repolarize <u>during</u> the QRS complex and therefore this repolarization is not separately detectable.

The sequence from P wave to T wave represents one heart cycle. The number of such cycles in a minute is called the **heart rate** and is typically 70-80 cycles (beats) per minute at rest.

Some typical times for portions of the EKG are given in Figure 3.

P-R interval ....120-200 milliseconds

QRS interval ....under 100 milliseconds

Q-T interval .....under 380 milliseconds

➤ **Note:** If your EKG does not correspond to the above numbers, DO NOT BE ALARMED! These numbers represent typical averages and many healthy hearts have data that fall outside of these parameters. To read a EKG effectively takes considerable training and skill. This sensor is NOT intended for medical diagnoses.*

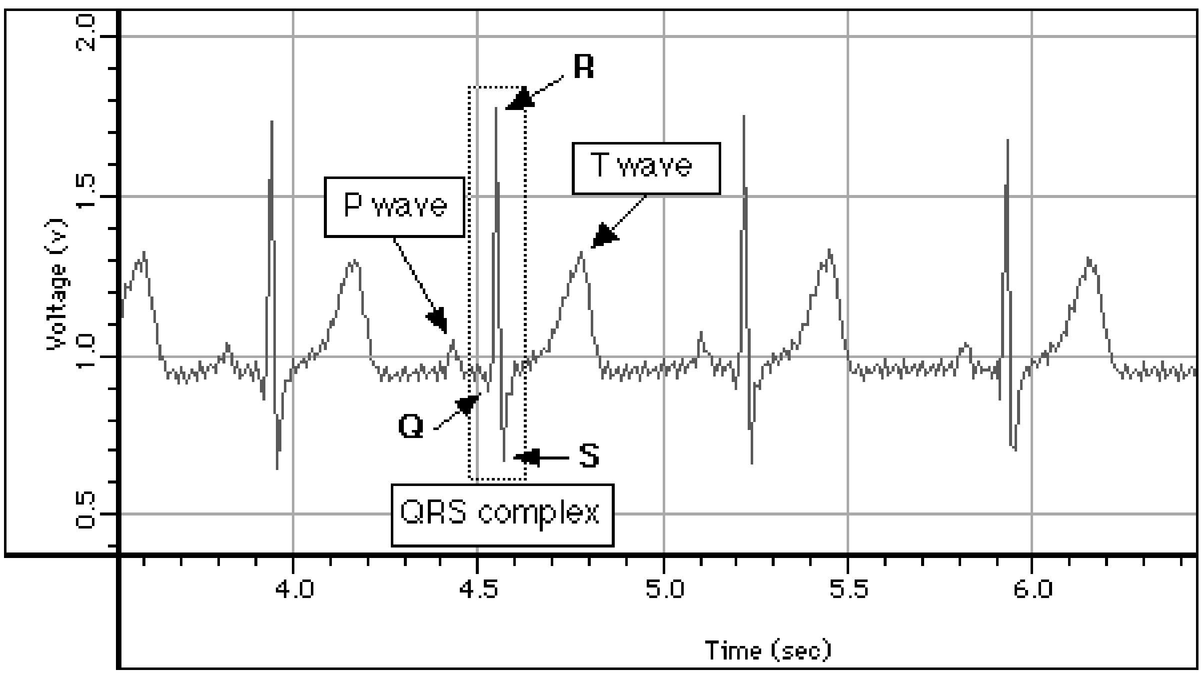


Figure 3
Sample EKG Graph

*Suggested Reading

The following are authoritative sources of information concerning the use of EKG machines and electocardiographs in medical practice.

Carr, Joseph J. and John M. Brown. *Introduction to Biomedical Equipment Technology*. New York: John Wiley & Sons, 1981.

Conover, Mary Boudreau. *Understanding Electrocardiography, Seventh Edition*. St. Louis: Mosby, 1996.

Wagner, Galen S. *Mariott's Practical Electrocardiography, Ninth Edition*. Baltimore: Williams and Wilkens, 1994.

Setup

Connecting the EKG Sensor to a Person

Use three electrode patches per subject. The electrodes can be reused but they tend to absorb moisture (they are very hygroscopic), and therefore, reuse is not recommended.

- Because the electrical signal produced by the heart and detected at the body's surface is so small, it is very important that the electrode patch makes good contact with the skin. Scrub the areas of skin where the patches will be attached with a paper towel to remove dead skin and oil.
- Avoid placing the electrodes over a large muscle, because the electrical activity of the muscle will interfere with sensing the voltage changes produced by the heart.

1. Peel three electrode patches from the backing paper. Firmly place the first electrode on the right wrist. Place a second electrode on the inside of the right elbow. Place the third electrode on the inside of the left elbow. (This is one of several possible arrangements for EKG electrodes on the body.) See Figure 5.

- Be sure to place the electrodes with the tabs oriented in such a way that the wire of the sensor can hang freely without twisting the edge of the electrode patch.

2. Connect the micro alligator clips from the sensor to the tabs on the edges of the electrode patches. See Figure 6.

- Connect the black (or "reference") alligator clip to the right wrist electrode patch. This is the reference point for the "Isoelectric" line (baseline).
- Connect the green (or negative) alligator clip to the right elbow electrode patch.
- Connect the red (or positive) alligator clip to the left elbow electrode patch.

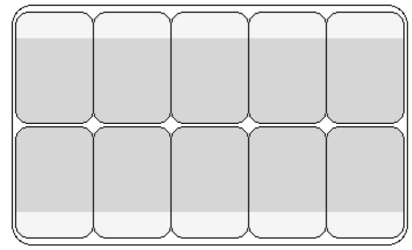


Figure 4
Electrode patches on backing paper

➤ **Note:** The electrodes should be kept in an airtight, clean, dry container for storage.

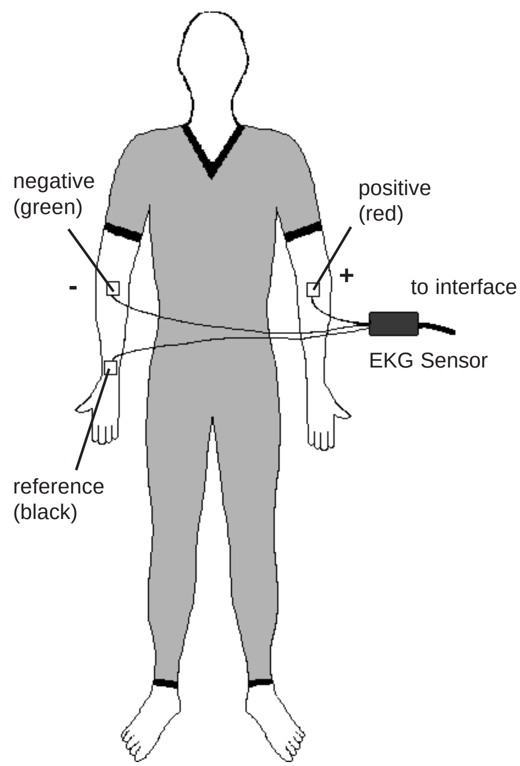


Figure 5
Connecting the EKG Sensor to a person

Using the EKG Sensor with *Science Workshop™ Interfaces*

The reading from the EKG Sensor in the *Science Workshop* software has been scaled to the millivolt range. The reading is adjusted so that zero volts represents the **Isoelectric line**.

1. Connect the EKG Sensor unit to analog channel A, B, or C of the *Science Workshop* computer interface box using the cable with the DIN connectors (Figure 7). Alternatively, the unit can be plugged directly into the analog channel jack.

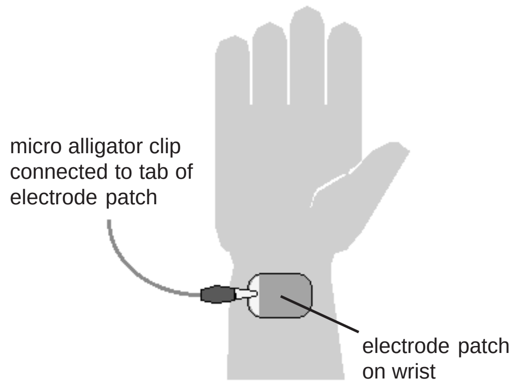


Figure 6
Connecting the micro alligator clips from the sensor to the tabs on the edges of the electrode patches

➤ **Note:** This instruction sheet was written assuming that the user is familiar with *ScienceWorkshop*. Users can gain familiarity by working through the tutorials provided with *ScienceWorkshop*.

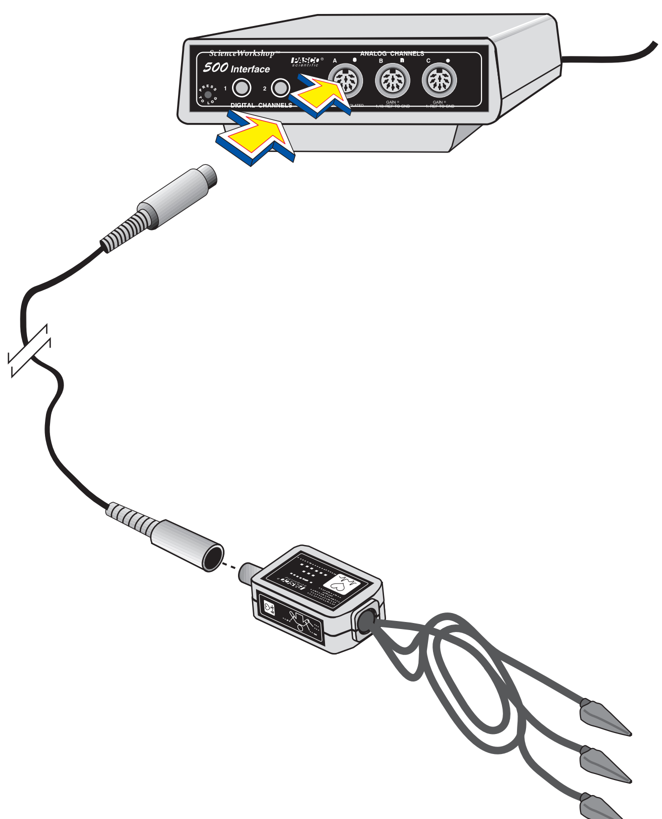


Figure 7
Connecting the EKG Sensor to the interface box

Suggested Experiments

Resting EKG

- Measure the EKG of a person who is at rest. The person whose EKG is being measured should remain calm and relaxed. Encourage the person to breath normally. Use the Graph to display the recorded data.
- Record the information specified in Table 1.1:
- Compare your values to the ones given earlier. What could explain the differences?

Table 1.1 Interval Analysis

Interval	Time (milliseconds)
P-Q	
QRS	
Q-T	

EKG after Mild Exercise

- Measure the EKG of a person who is initially at rest. Disconnect the sensor wires from the electrode patches, but leave the patches on the person whose EKG is being measured. Have the person exercise for three minutes by jogging in place or by “stepping-in-time”.
- Reattach the sensor wires to the electrodes on the person within thirty seconds after the exercise is done, and measure the EKG.

Compare the EKG after mild exercise to the rest EKG.

EKG and Different Body Positions

- Use body position as your independent variable. Measure the rest EKG as before. Then have the person sit or stand or lie down. Make no other changes. Note any changes in heart rate, interval times, height of R wave, etc. In other words, compare your results with your rest EKG.

Table 1.2 Heart Rate Analysis

Item	Rate (per minute)
Minimum	
Maximum	
Average	

EKG and Mild Stimulants

- Drink a couple of cups of strong caffeinated coffee as your independent variable. (This might show less effect on people who are accustomed to large amounts of coffee.) Compare your results with the resting EKG results and mild exercise EKG results.

Technical Support

Feedback

If you have any comments about the product or manual, please let us know. If you have any suggestions on alternate experiments or find a problem in the manual, please tell us. PASCO appreciates any customer feedback. Your input helps us evaluate and improve our product.

To Reach PASCO

For technical support, call us at 1-800-772-8700 (toll-free within the U.S.) or (916) 786-3800.

fax: (916) 786-3292

e-mail: techsupp@pasco.com

web: www.pasco.com

Contacting Technical Support

Before you call the PASCO Technical Support staff, it would be helpful to prepare the following information:

➤ If your problem is computer/software related, note:

- Title and revision date of software;
- Type of computer (make, model, speed);
- Type of external cables/peripherals.

➤ If your problem is with the PASCO apparatus, note:

- Title and model number (usually listed on the label);
- Approximate age of apparatus;
- A detailed description of the problem/sequence of events (in case you can't call PASCO right away, you won't lose valuable data);
- If possible, have the apparatus within reach when calling to facilitate description of individual parts.

➤ If your problem relates to the instruction manual, note:

- Part number and revision (listed by month and year on the front cover);
- Have the manual at hand to discuss your questions.