EARTH'S SEASONAL HEAT ABSORPTION AND CLIMATE REGIONS MODEL

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The Insolation Model we have constructed is intended for classroom use. The instructional use of the model fits squarely within the curricular requirements of a course in Earth Science in New York State. Eighth or ninth grade students are expected to understand that the Earth is a sphere and that its curvature, as one travel away from the equator is directly related to surface temperature absorption on our planet. The primary function of this model demonstrates that with the same heat source directed towards the sphere, the temperatures at the higher latitudes are less than the temperature at the equator. The model also can rotate on a horizontal axis to demonstrate the temperature absorption difference with the tilt of the Earth towards the Sun at the start on each of the four seasons.

The model operates in the following manner: when the heat generated by a lamp is directed towards the sphere, three (3) heat sensors located at points approximating the equator, 45º north latitude and the north pole, "read" the temperature. Three (3) LED's on the globe, corresponding to the same latitudes as the heat sensors respond to the temperature readings. They all begin at a "cool" green. As the <u>difference</u> in temperatures rises, the LED's change color. If the temperature between the North Pole and any of the other two LED's is only moderate, then they show a mixed green and red color. However if the temperature difference between the north pole and another sensor is significant, the LED corresponding to that sensor will turn red. The LED's automatically change color according to the difference in temperature among the three regions, using the pole as the standard. The information taught by this model is that both visual and intuitive.

In addition to the automatic response of the LED's to the temperature sensors, an LCD screen displays the real-time temperature readings of the heat sensors in degrees Celsius. Thus, the input from the three independent heat sensors automatically generates a distinct response in three separate LED's, and automatically integrates the three temperature readings into a single display.

The usefulness of the model is increased by its ability to rotate the sphere by use of a dial-controlled servo motor which can move the sphere into the proper tilt positions to imitate the attitude and tilt of the Earth towards the Sun on the first day of each of the four seasons. Additionally, because the lamp (as heat source) is independent, it can be moved closer to or farther away from the globe, to indicate how, if a planet were either too close to or too far from its sun, it would be too hot or too cold to support life.

HOW THE MODEL WORKS

There are four mechatronic systems operating in the Model: (1) the retrieval of temperature readings from the 3 heat sensors, (2) the generation of different signals to light up the three LED's based on the temperature readings, (3) the display of the actual temperature readings on a LCD display mounted above and behind the globe and (4) the control of the servo motor to move the globe into the desired tilt position.   Physically, the model consists of a globe suspended on a horizontal bar drilled through the center of the sphere. The bar itself is supported on two ends; it is attached to the servo-motor at one end while the bar can spin freely on its support at the other end. Mounted onto the horizontal base are the dial to control the servo motor and the electronic circuit board (the "breadboard"), from which wires run to the globe, the dial, the servo-motor and the LCD display. The control of the devices, whether autonomous or not, is accomplished by use of a microcontroller chip and software connected to the breadboard by use of a 15-pin serial connector.

The Temperature Sensors

The three temperature readings are obtained from three analog temperature sensors, AD592s. These devices are not thermometers and do not register a temperature directly. Instead they generate an electrical current at a constant rate, so that as they grow warmer, they throw off more current. The amount of current thrown off is measured indirectly. Connecting a processor to a circuit with a resistor and a capacitor together with the AD592, the processor can count the time (actually, the number of clock cycles) necessary for the capacitor to charge from the AD592. This number can then be converted into a temperature reading. It must be noted that the arithmetic necessary to compute temperature uses a "constant". Because each circuit and each devise contains minute variations, by changing the constant, you can "force" reasonably accurate, and consistent temperature readings from the different sensors.

Although our model uses the resistor and capacitor combination to calculate the time to **charge** the capacitor, one can set up the circuit to count the time necessary to **discharge** the capacitor. In fact, this was our first approach, but it was abandoned in favor of "charging" the capacitor because the latter is more accurate. When measuring the discharge time, the processor is measuring the smaller interval between 0 and 1.3 volts. The measurement is more reliable over the larger interval from 1.3 to 5.0 volts when looking at charging time.

The LED's

The charge time for each temperature sensor is converted to a temperature and saved to its own variable in the software program. The software compares the temperatures received from the sensors every two seconds. In fact, the first time the processor receives a temperature value for each sensor, it turns on its corresponding green LED. The temperatures are then compared. Using the sensor at the north pole as the reference value, readings that are less than three degrees different from the pole's will continue to generate only a green LED. Differences of 3 or 4 degrees generate both green and red impulses to the LEDs and differences of 5 or more generate only red signals to the LEDs.

The LCD Display

The temperature readings, having been saved to variables, are then displayed through a serial pin LCD Display. Although a parallel LCD display offers many advantages, it would require six pins from the processor, whereas the serial version requires only one pin from the processor. This model uses 3 processor pins for the heat sensors, 6 pins for the LEDs, 1 pin for the servo-motor and 1 pin for the dial that controls the motor. There is only 1 pin left, which thankfully is enough for the serial LCD display. Through the use of software variables and careful spacing, all three temperature readings are presented simultaneously. The ability to create custom characters (pixel by pixel) allowed us to insert the degree symbol(" º ").

Tilting the Globe

A knob controls the "tilt" of the globe. The knob is a potentiometer connected to a resistor-capacitor circuit. As the knob turns, the RC time changes, which number is saved to a software variable. That number will fall into one of three divisions of the total range of values generated by the RC timer. Each of these three sections of the range will generate an impulse either clockwise or counterclockwise, or no impulse at all.