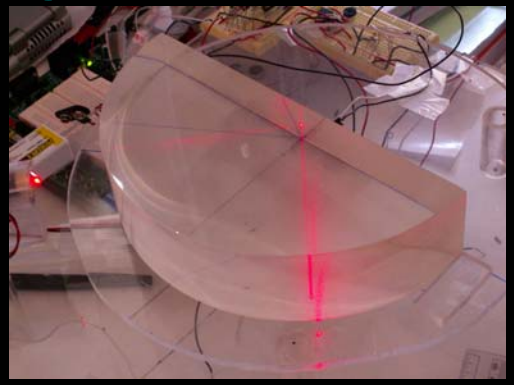
POLYTECHNIC UNIVERSITY

SMART Program

Professor Vikram Kapila

Team 5 Project:

“Finding The Critical Angle”



Mustafa Kilic, Math Teacher, Brooklyn Amity School

Thomas Byrne, Physics Teacher, New Rochelle High School

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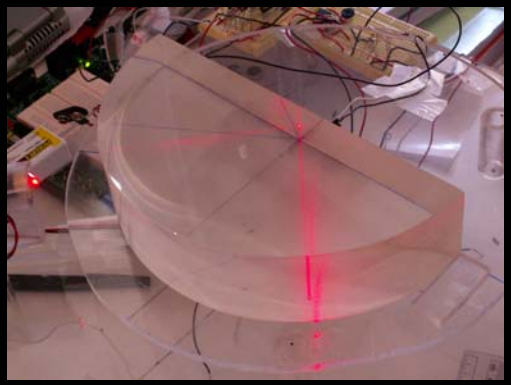
“Finding The Critical Angle”



Mustafa Kilic, Math Teacher, Brooklyn Amity School

Thomas Byrne, Physics Teacher, New Rochelle High School

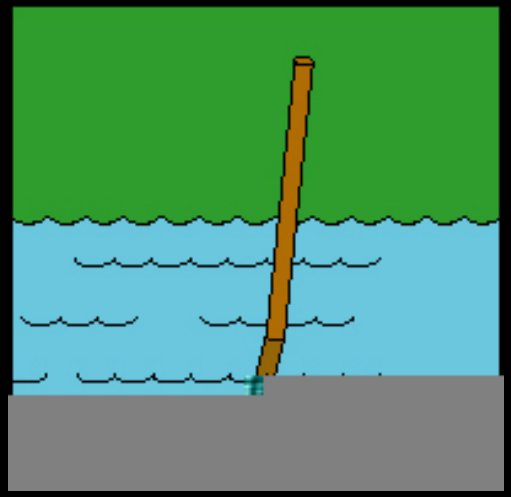
and Nathan (Sang-Hoon) Lee

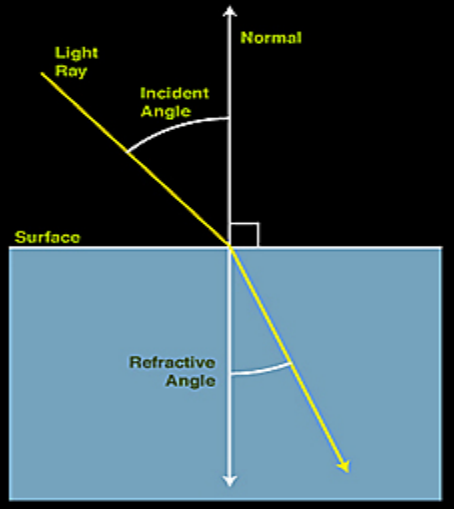
Project Objective:

1. Design a device that will demonstrate total internal reflection of light as it moves from an optically slower to an optically faster medium.
2. Incorporate at least one sensor and one actuator into the device along with the Base Stamp2 microcontroller.

CONCEPTS UNDERLYING OUR PROJECT

1. REFRACTION OF LIGHT: AS THE SPEED OF LIGHT CHANGES WHEN LIGHT TRAVELS FROM ONE MEDIUM INTO ANOTHER, THE DIRECTION OF THE LIGHT ALSO CHANGES.





CONCEPTS UNDERLYING OUR PROJECT

2. INDEX OF REFRACTION: A CHARACTERISTIC OF ALL TRANSPARENT MEDIA. IT IS A RATIO OF THE SPEED OF LIGHT IN A VACUUM TO THE SPEED OF LIGHT IN THE MEDIUM.

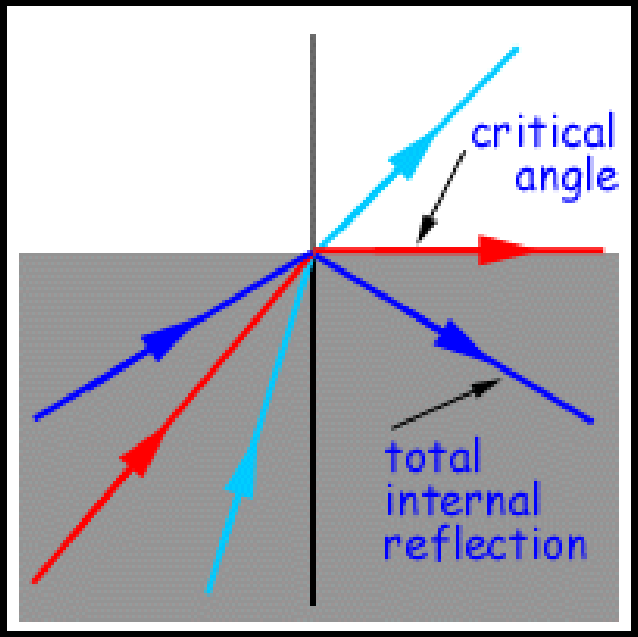
   THE HIGHER THE INDEX OF REFRACTION, THE SLOWER LIGHT TRAVELS IN THAT SUBSTANCE.

   SNELL'S LAW:

   $n_1 * \sin(\theta_1) = n_2 * \sin(\theta_2)$

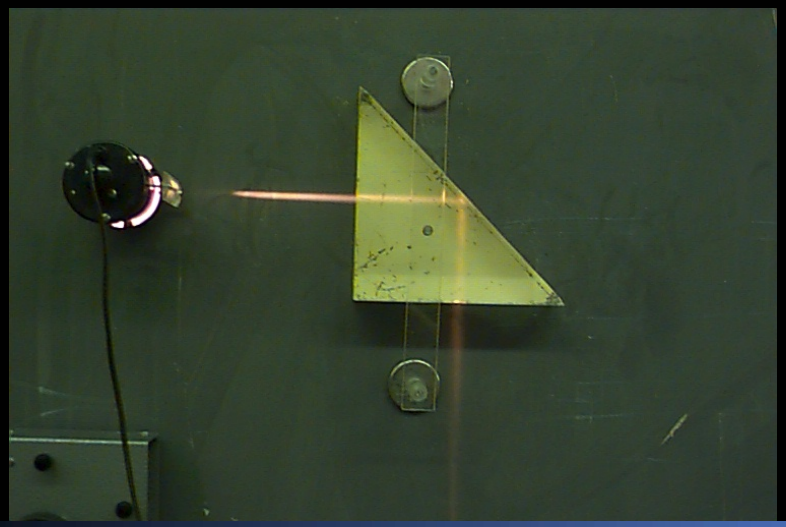
CONCEPTS UNDERLYING OUR PROJECT

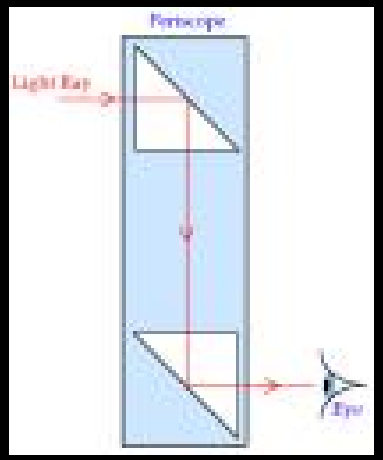
3. CRITICAL ANGLE: THE ANGLE OF INCIDENCE IN A MEDIUM THAT RESULTS IN AN ANGLE OF REFRACTION OF 90 DEGREES (PARALLEL TO A HORIZONTAL BOUNDARY).



CONCEPTS UNDERLYING OUR PROJECT

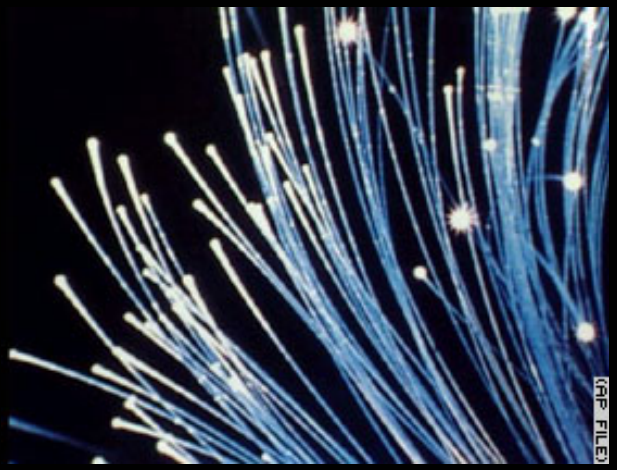
4. TOTAL INTERNAL REFLECTION: WHEN THE ANGLE OF INCIDENCE EXCEEDS THE CRITICAL ANGLE, THE LIGHT DOES NOT EXIT THE INCIDENT MEDIUM BUT TOTALLY REFLECTS BACK INTO IT. THE LAW OF REFLECTION GOVERNS THIS REFLECTED RAY.

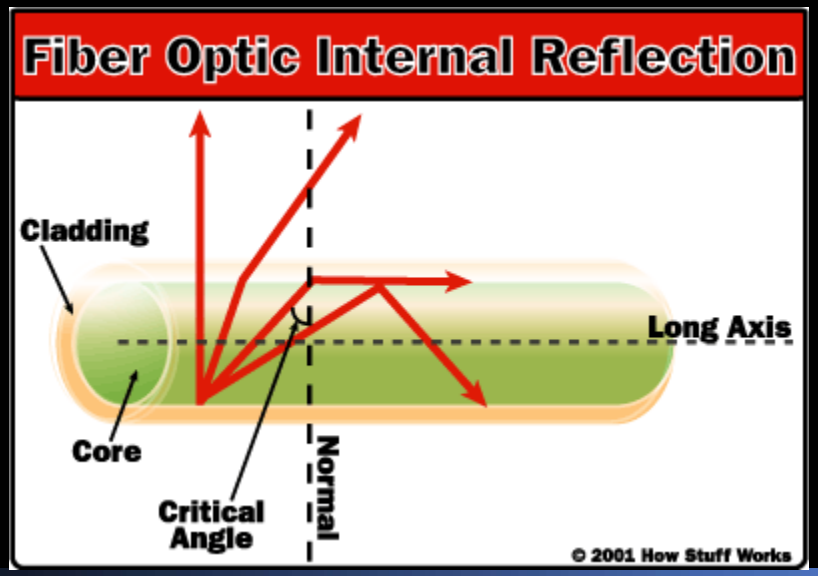


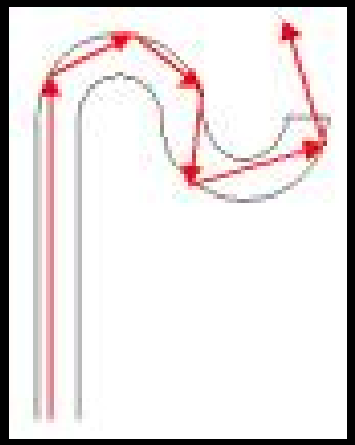


APPLICATIONS OF TOTAL INTERNAL REFLECTION

1. FIBER OPTICS: Transmission of digital information

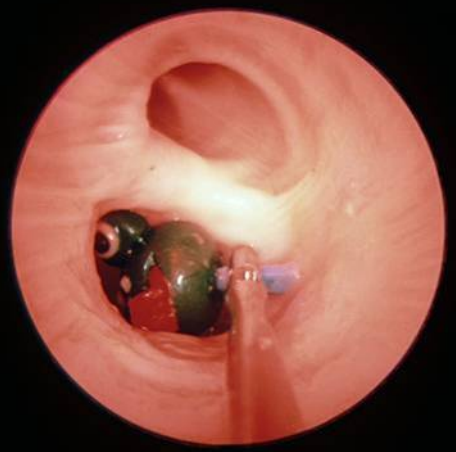


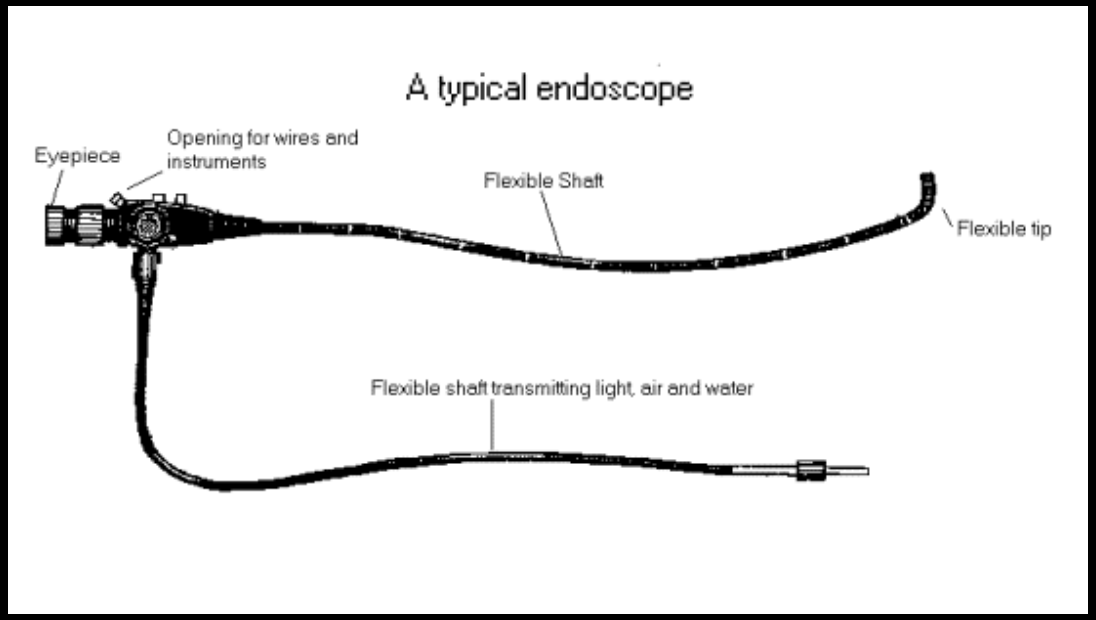




APPLICATIONS OF TOTAL INTERNAL REFLECTION

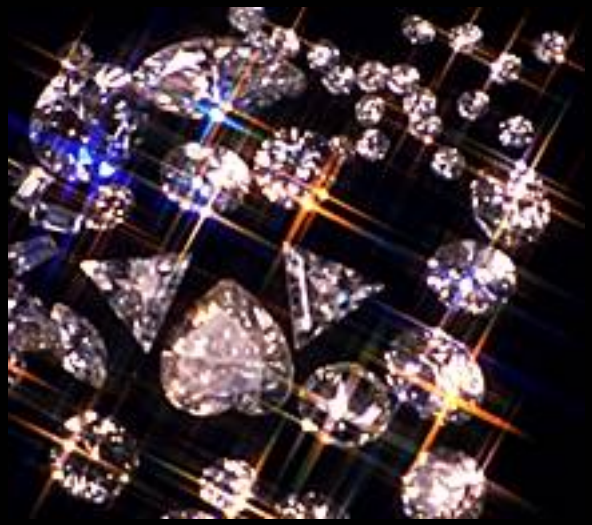
2. ENDOSCOPE: Minimally invasive diagnostic device

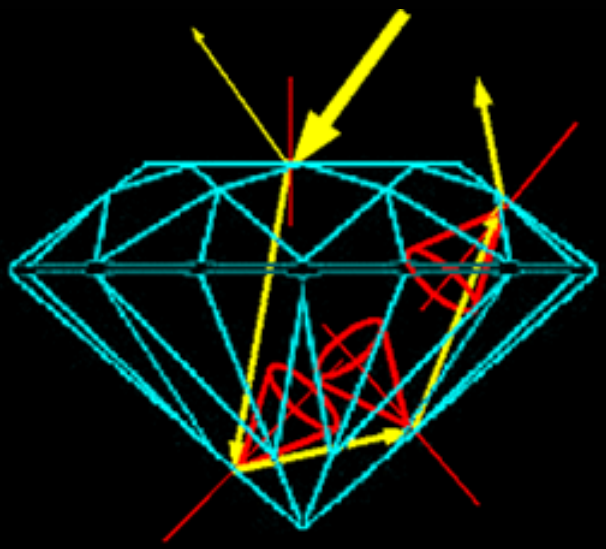




APPLICATIONS OF TOTAL INTERNAL REFLECTION

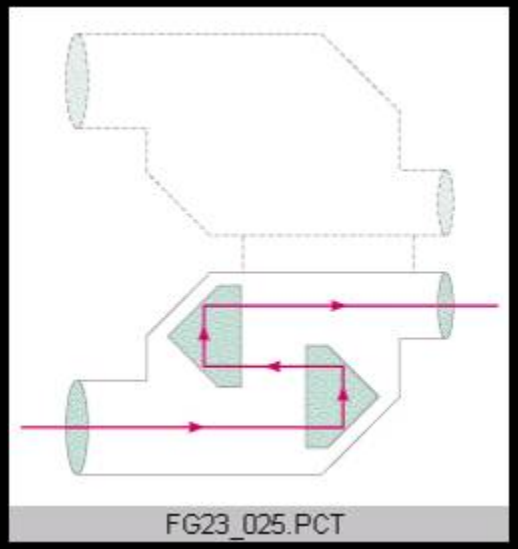
3. CUT OF DIAMONDS:

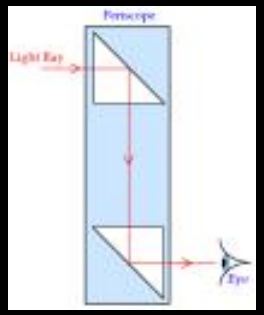




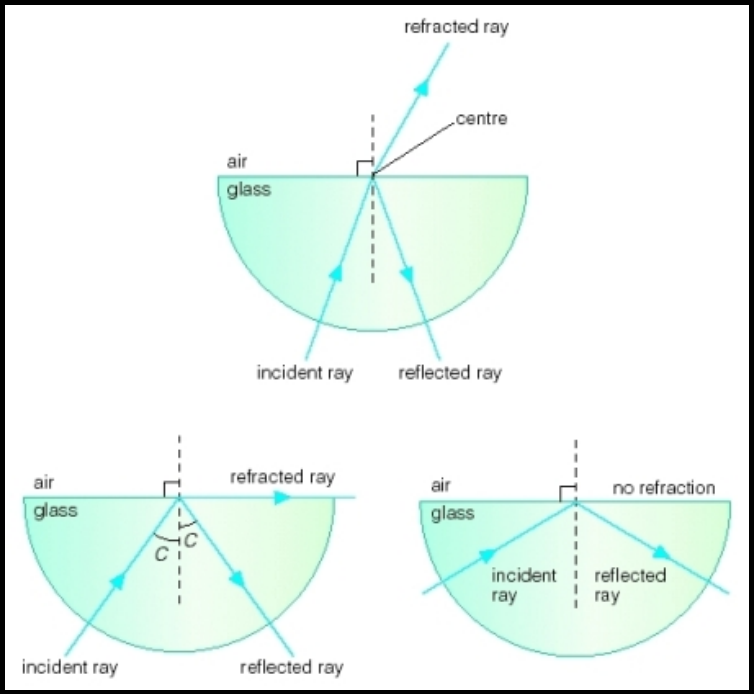
APPLICATIONS OF TOTAL INTERNAL REFLECTION:

4. BINOCULARS AND PERISCOPES:



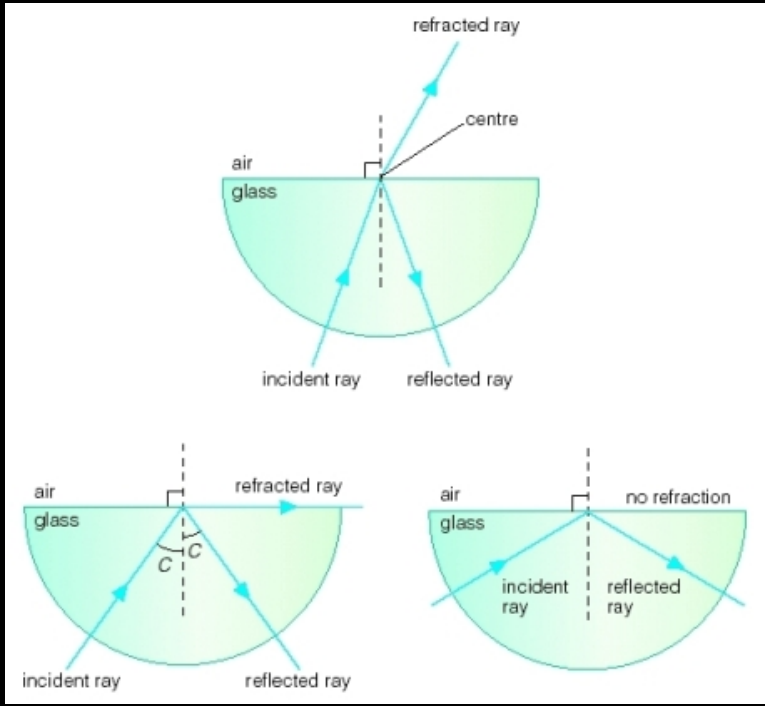


OVERVIEW OF DEVICE



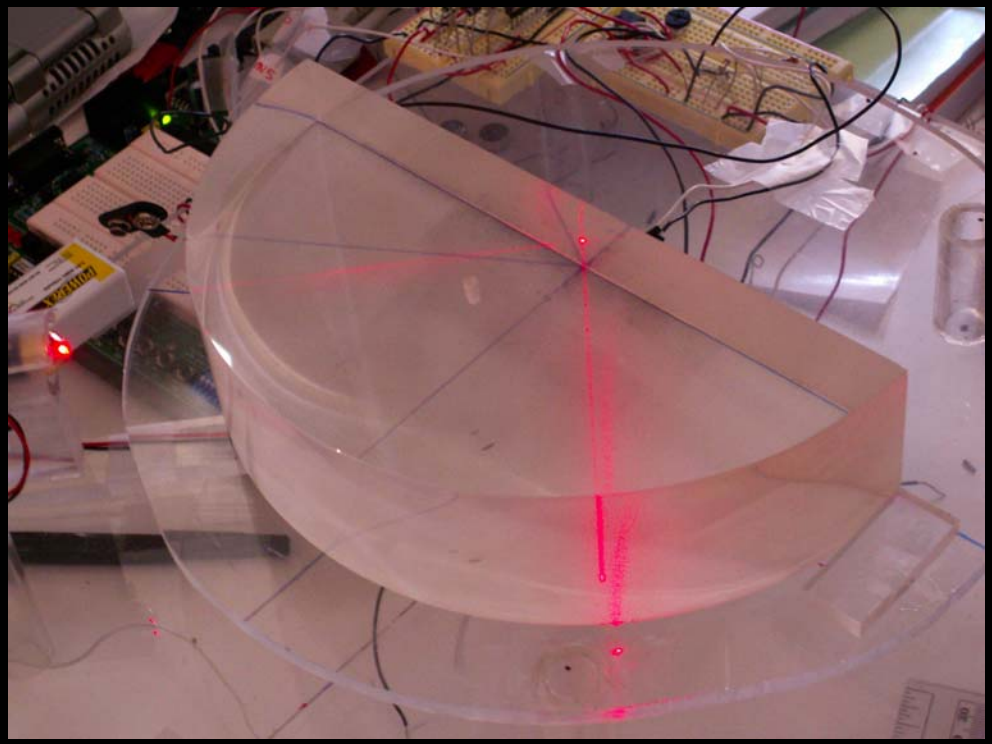
1. LIGHT ENTERS THE PRISM ALONG THE NORMAL ($\Theta_i = 0°$).
2. LASER IS ROTATED BY DC MOTOR AROUND THE PRISM, THEREBY SLOWLY INCREASING THE ANGLE OF INCIDENCE.

OVERVIEW OF DEVICE



3. REFRACTED LIGHT EXITS THE PRISM AND HITS THE LIGHT SENSOR (PHOTORESISTOR).
4. WHEN THE LASER REACHES THE CRITICAL ANGLE OF THE PRISM, THE LIGHT REFRACTS PARALLEL TO THE BOUNDARY OF THE PRISM.

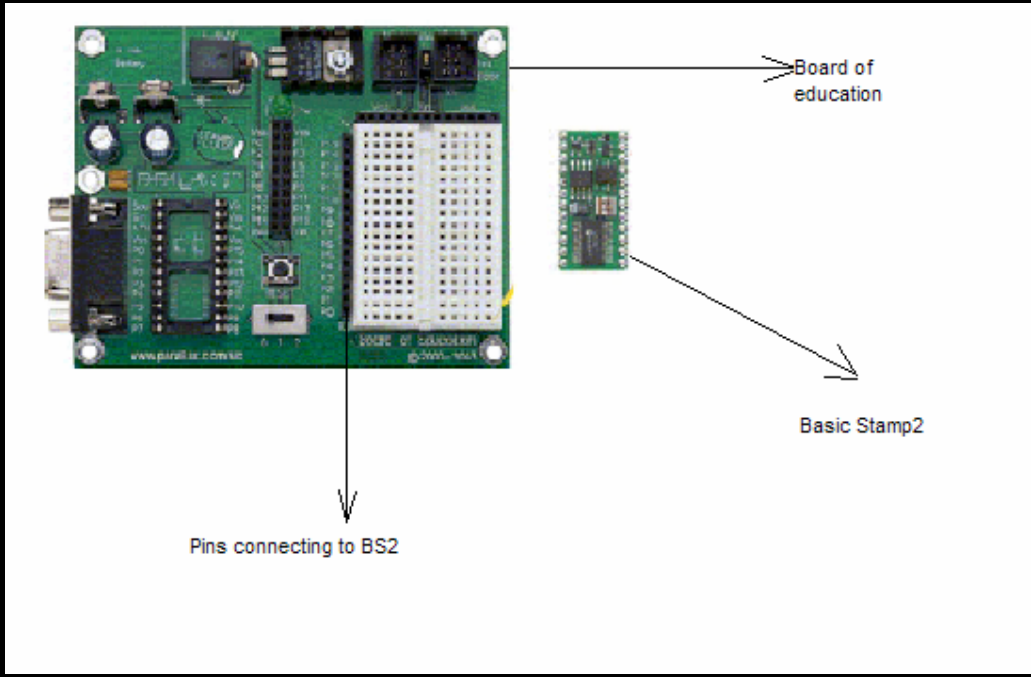
OVERVIEW OF DEVICE



5. WHEN THE LASER PASSES THE CRITICAL ANGLE THE LIGHT UNDERGOES TOTAL INTERNAL REFLECTION.
6. THE SENSOR DETECTS THIS OCCURRENCE AND STOPS THE MOTOR. THE DEVICE MEASURES THE CRITICAL ANGLE OF THE PRISM.

COMPONENTS OF THE DEVICE

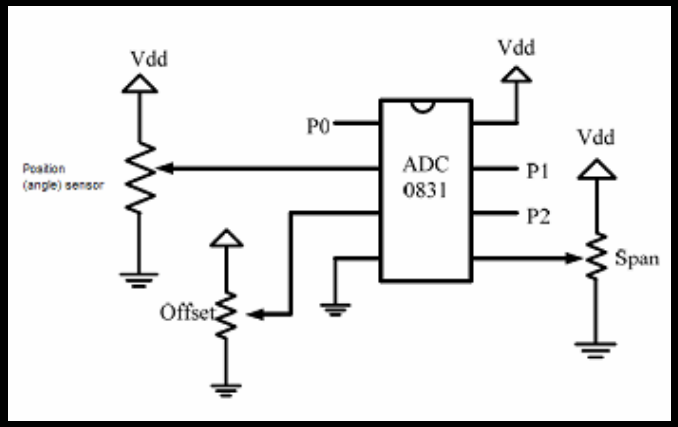
1. BASE STAMP2 MICROCONTROLLER AND BOARD OF EDUCATION:



COMPONENTS OF THE DEVICE

2. SENSORS

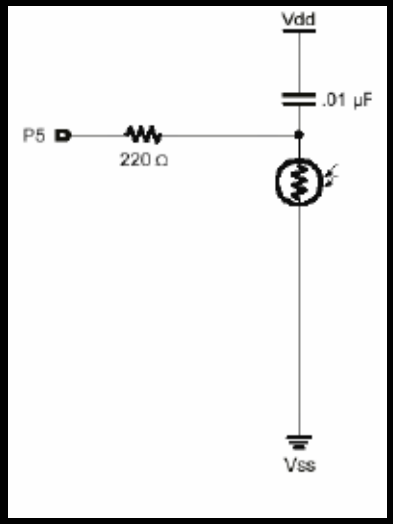
A. THREE 10K Ω ROTARY POTENTIOMETERS – CAUSE CHANGE IN VOLTAGE AS RESISTANCE CHANGES. THEY WORK IN CONJUNCTION WITH ADC 0813 CHIP – ANAOLOG TO DIGITAL CONVERSION CHIP



COMPONENTS OF THE DEVICE

2. SENSORS (cont'd)

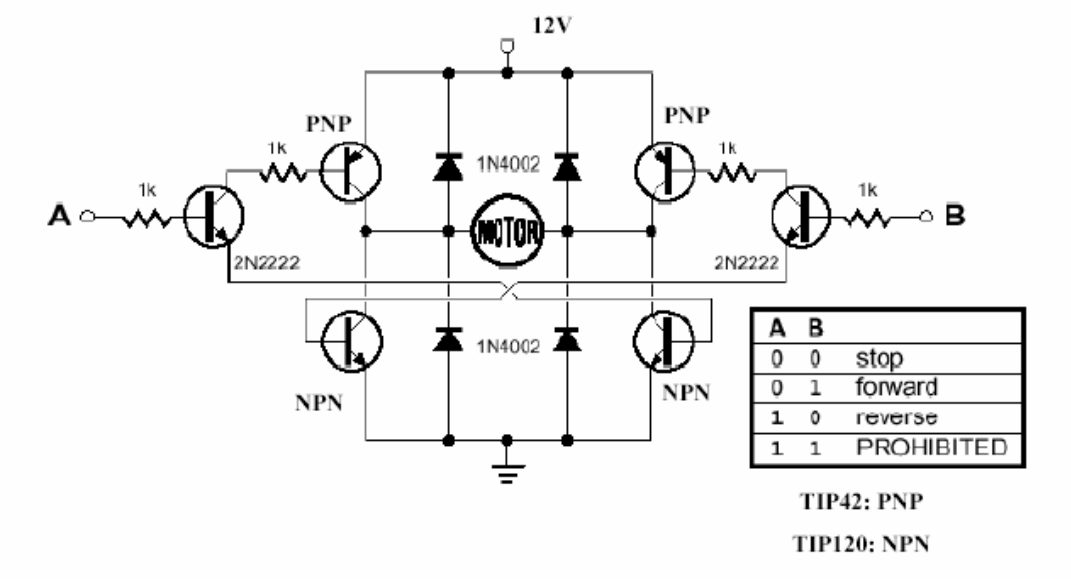
B. PHOTORESISTOR – RESISTANCES INCREASES AS LIGHT INTENSITY DECREASES. ACTS AS A LIGHT SENSOR IN CONJUNCTION WITH CAPACITOR



COMPONENTS OF THE DEVICE

3. ACTUATOR

DC MOTOR, in conjunction with an H-Bridge to allow the motor to reverse direction in order to return the laser to its starting position.



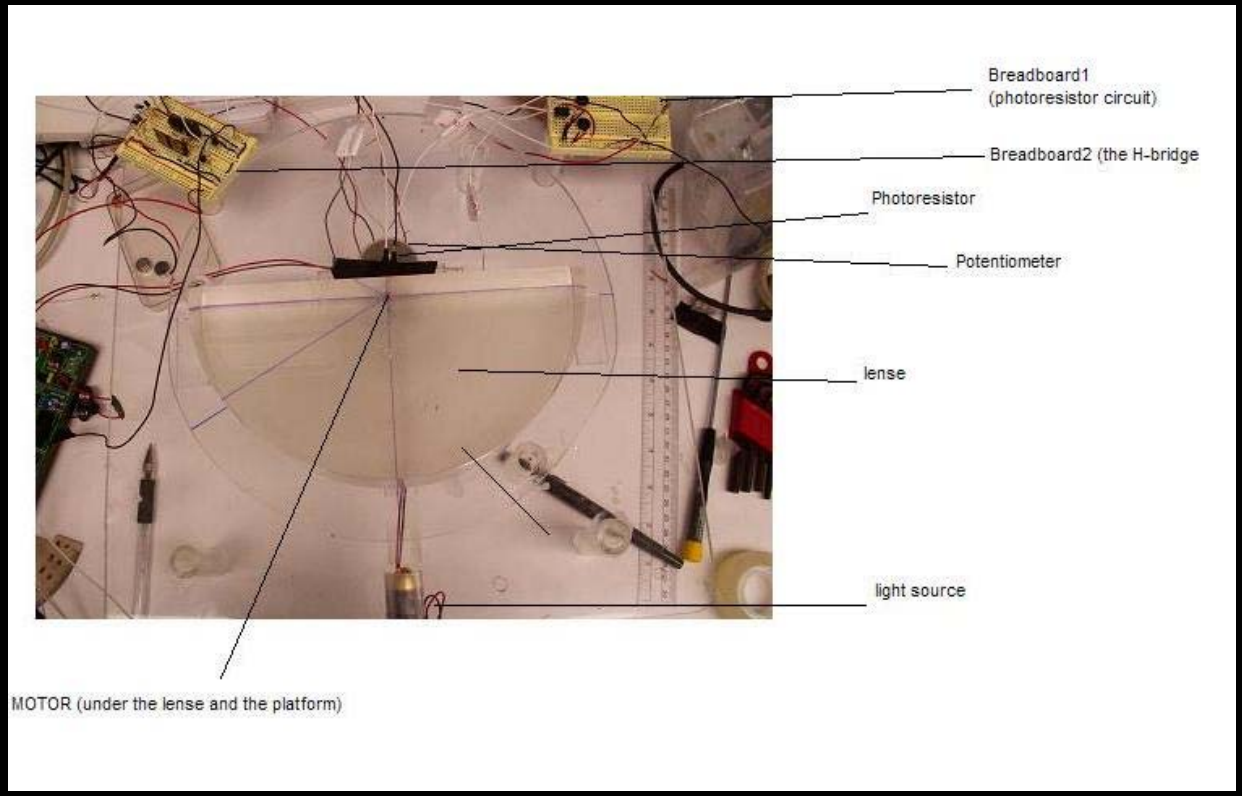
COMPONENTS OF THE DEVICE

4. PBASIC COMPUTER PROGRAM

   THE SET OF INSTRUCTIONS FOR THE MICROCONTROLLER WHICH ENABLES THE DEVICE TO PERFORM ITS FUNCTIONS IN THE PROPER ORDER.

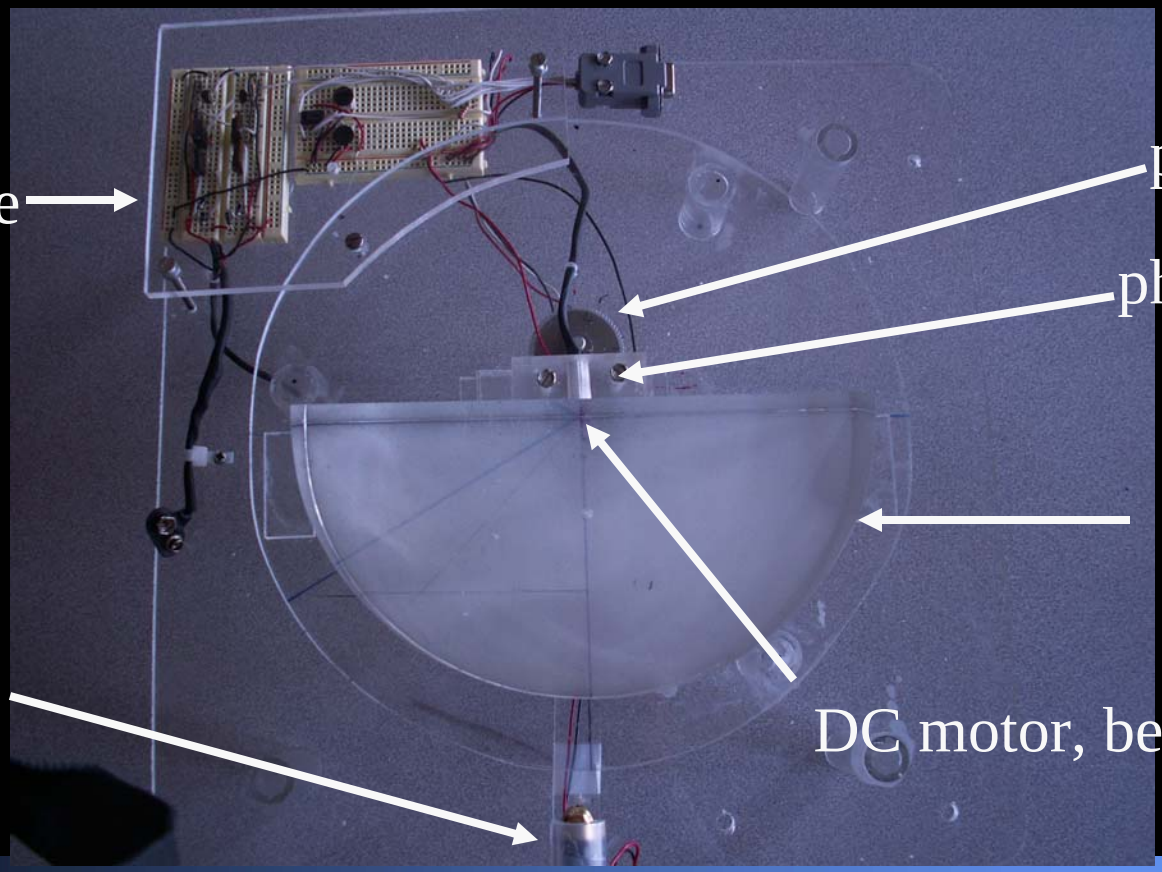
COMPONENTS OF THE DEVICE

5. THE “CRITICAL ANGLE MEASURING DEVICE”:



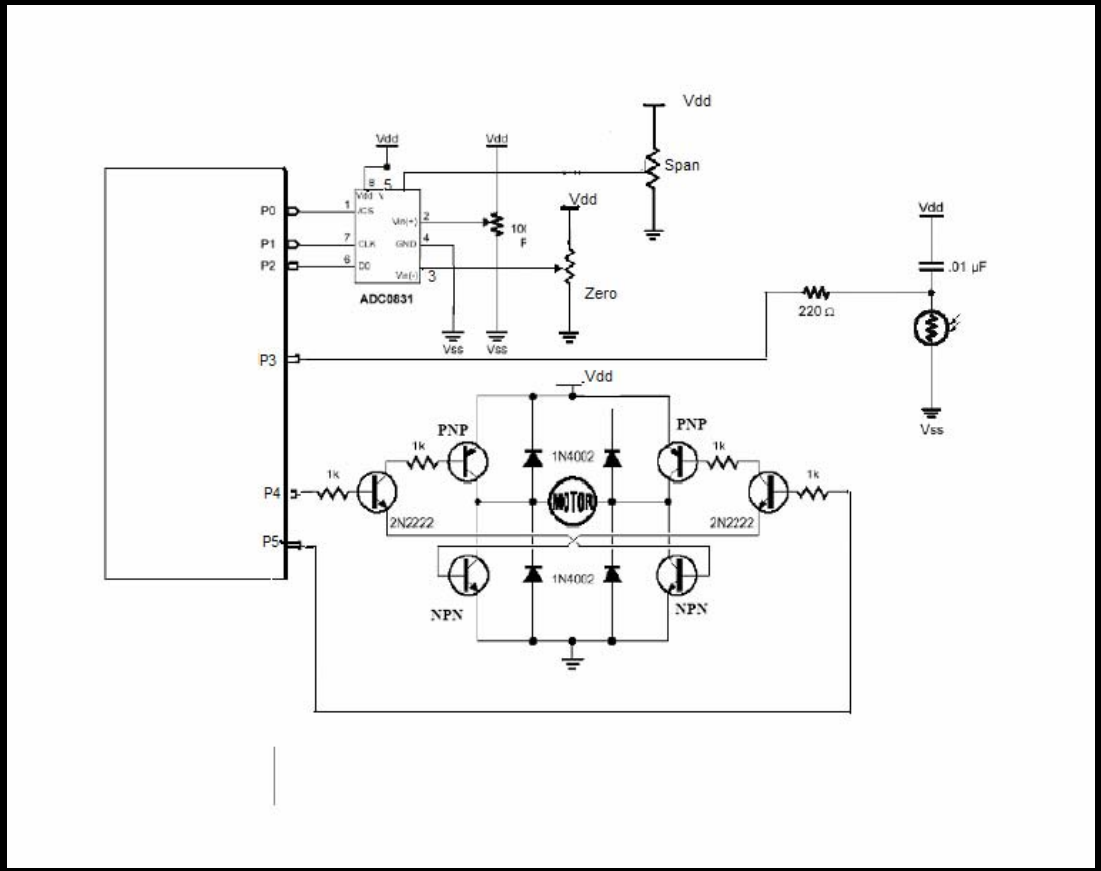
COMPONENTS OF THE DEVICE

5. THE “CRITICAL ANGLE MEASURING DEVICE”:



COMPONENTS OF THE DEVICE

5. THE “CRITICAL ANGLE MEASURING DEVICE”:



OBSTACLES ENCOUNTERED

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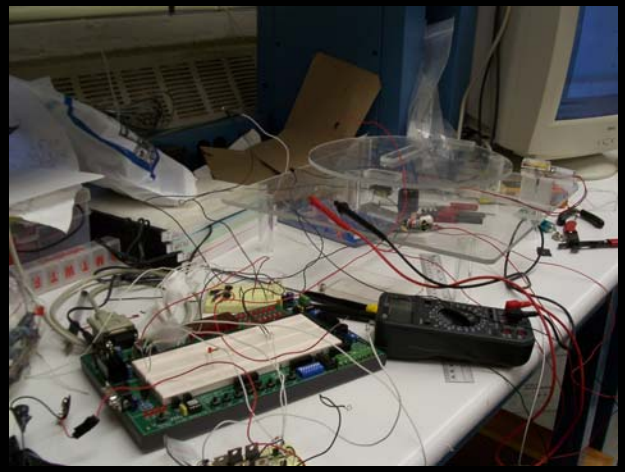
1. DC MOTOR:

   - MANUAL ROTATION WHEN WORKING WITH GEARS

   - VOLTAGE DROP CAUSED BY USE OF H-BRIDGE



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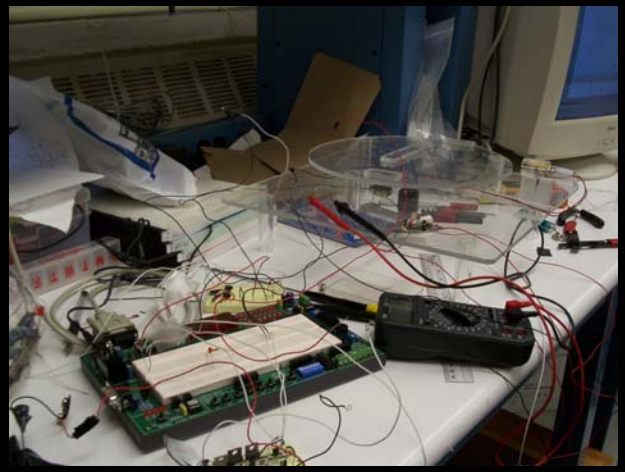


SOLUTION:

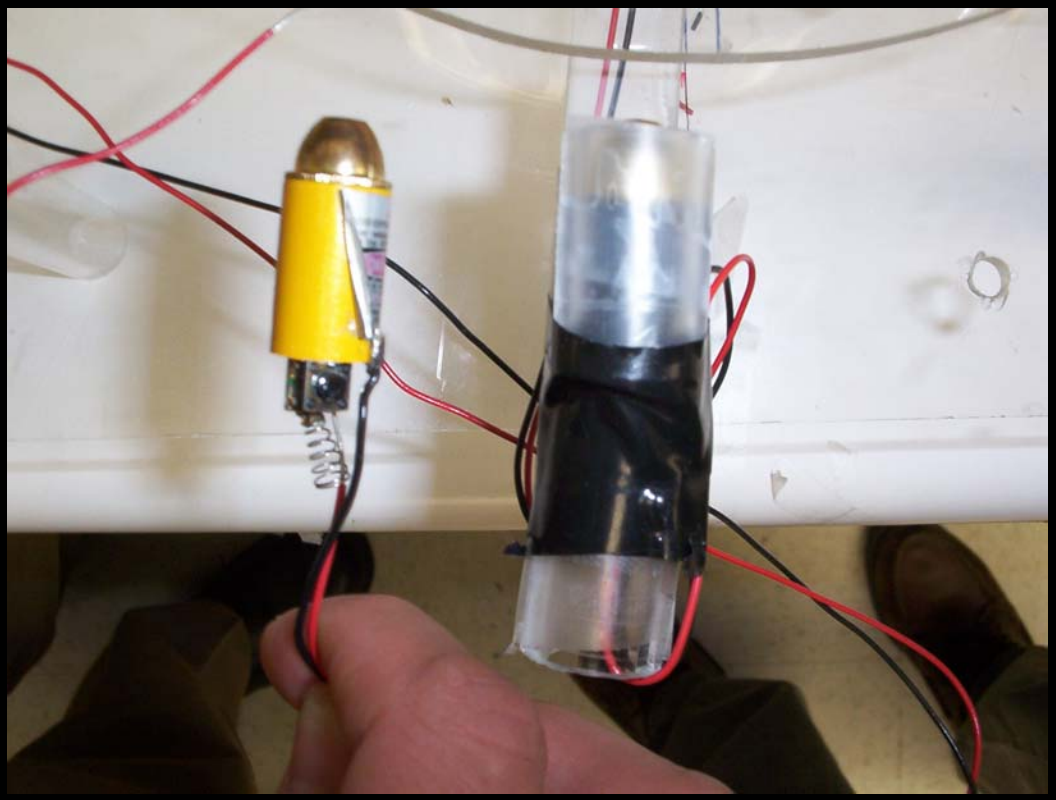
SIR NATHAN

OBSTACLES ENCOUNTERED

2. ANGLE MEASUREMENT STOPPING AT 60 DEGREES

OBSTACLES ENCOUNTERED

3. LASER INTENSITY



ACKNOWLEDGEMENTS

PROFESSOR VIKRAM KAPILA

POLYTECHNIC UNIVERSITY, SMART PROGRAM

ACKNOWLEDGEMENTS

NATHAN (SANG-HOON) LEE

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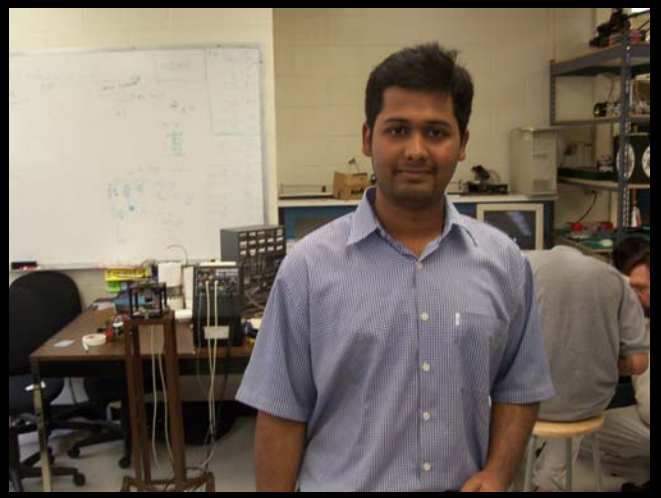
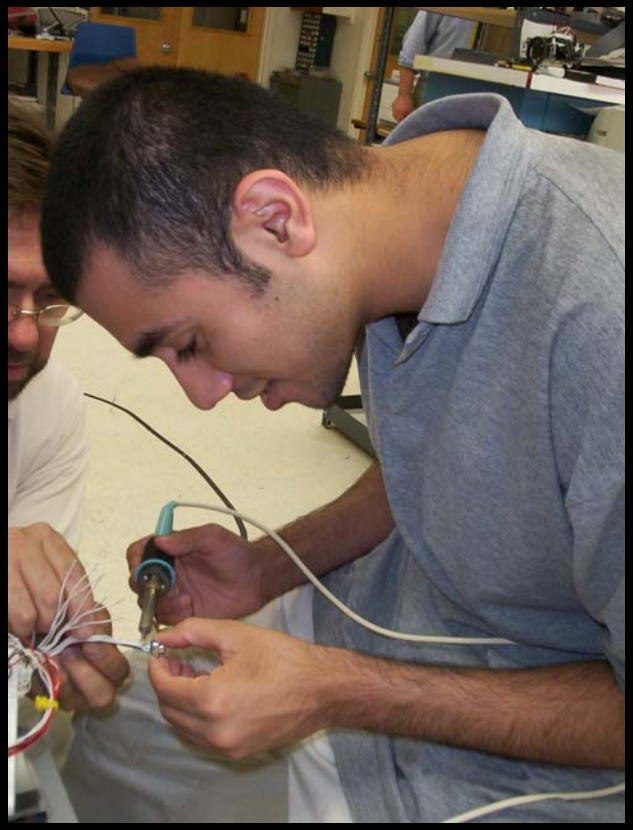
ANSHUMAN PANDA



ALEX BETTI

ACKNOWLEDGEMENTS

FARHAN MUDASIR



ALL STUDENT FELLOWS

ACKNOWLEDGEMENTS

NATIONAL SCIENCE FOUNDATION

COLLEAGUES IN SMART PROGRAM SUMMER 2005