CATCH ME IF YOU CAN

BY

JOHN LUVERA

MONTVILLE HIGH SCHOOL

AND

MICHAEL MCDONNELL

MIDWOOD HIGH SCHOOL

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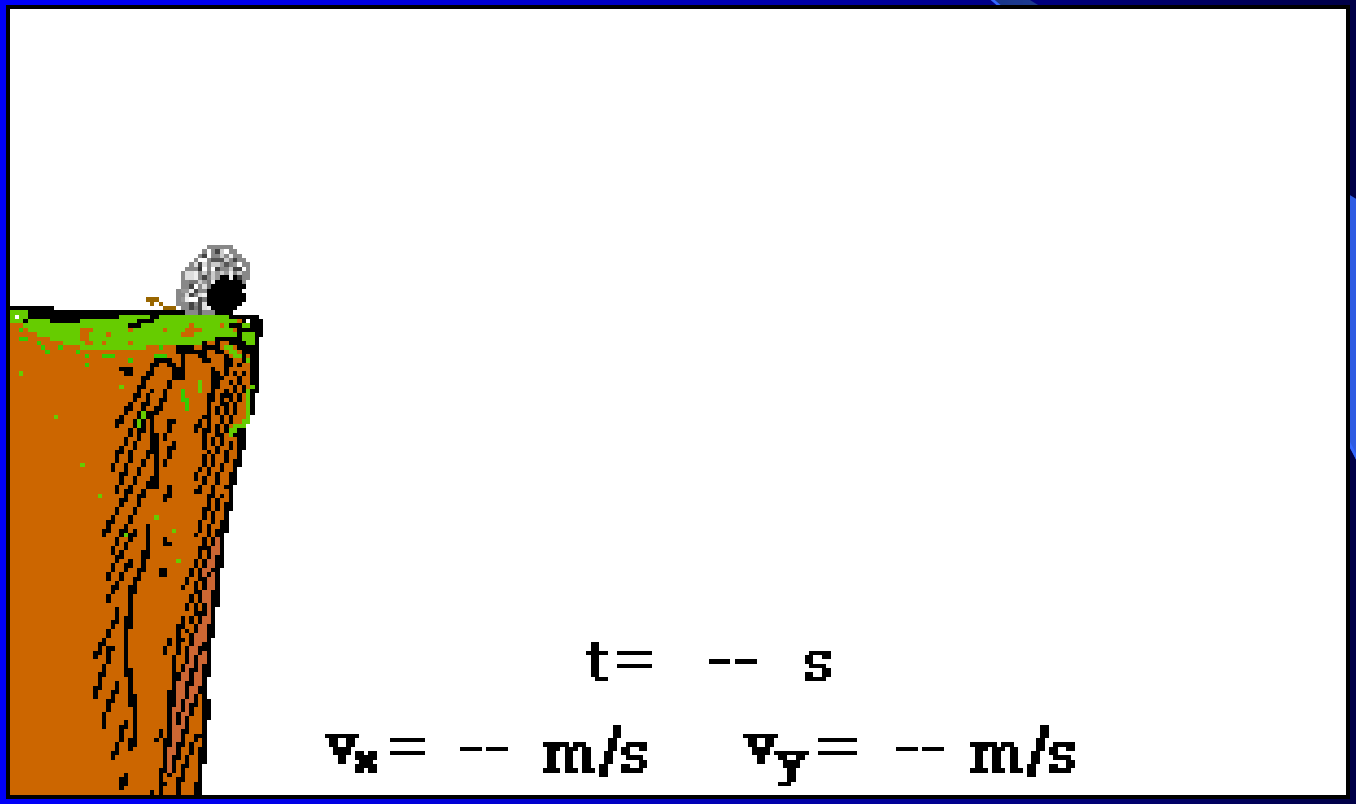
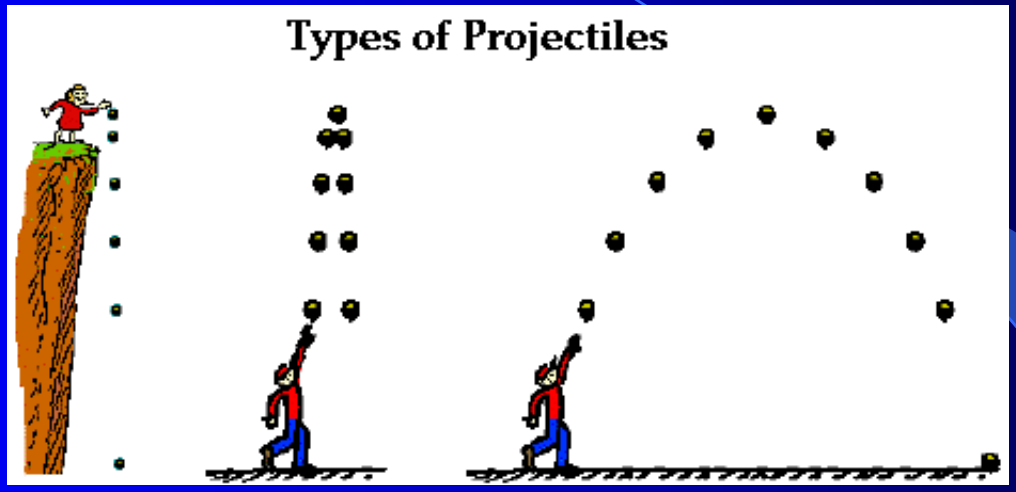
SMART **S**cience and **M**echatronics **A**ided **R**esearch for **T**eachers **2003—2005**

GOAL

PROJECTILE MOTION PROJECT



BACKGROUND



• Projectile Motion describes the motion of an object, in at least two dimensions, and experiences that force of gravity in the vertical direction.

•A projectile's horizontal velocity is constant because it experiences no net force in the horizontal direction. A projectile's vertical velocity is not constant as it experiences a net force downward, equal to the weight of the object.

BACKGROUND II

$$V = V_{oy} + at = 0$$

$$t = \frac{V_{oy}}{g}$$

$$t = \frac{2V_{oy}}{g} = \frac{2V_o \sin\theta}{g}$$

$$x = V_o x t = \frac{V_o \cos\theta \left(2V_o \sin\theta\right)}{g}$$

$$x = \frac{V_o^2 \sin 2\theta}{g}$$

STANDARDS

New York State Physics Standards—Commencement Level

- 4.1 Energy exists in many forms, and when these forms change energy is conserved.
- 5.1 Explain and predict different patterns of motion of objects (e.g., linear and uniform.
- 5.1g A projectile's time of flight is dependent upon the vertical component of its motion.
- 5.1h The horizontal displacement of a projectile is dependent upon the horizontal component.

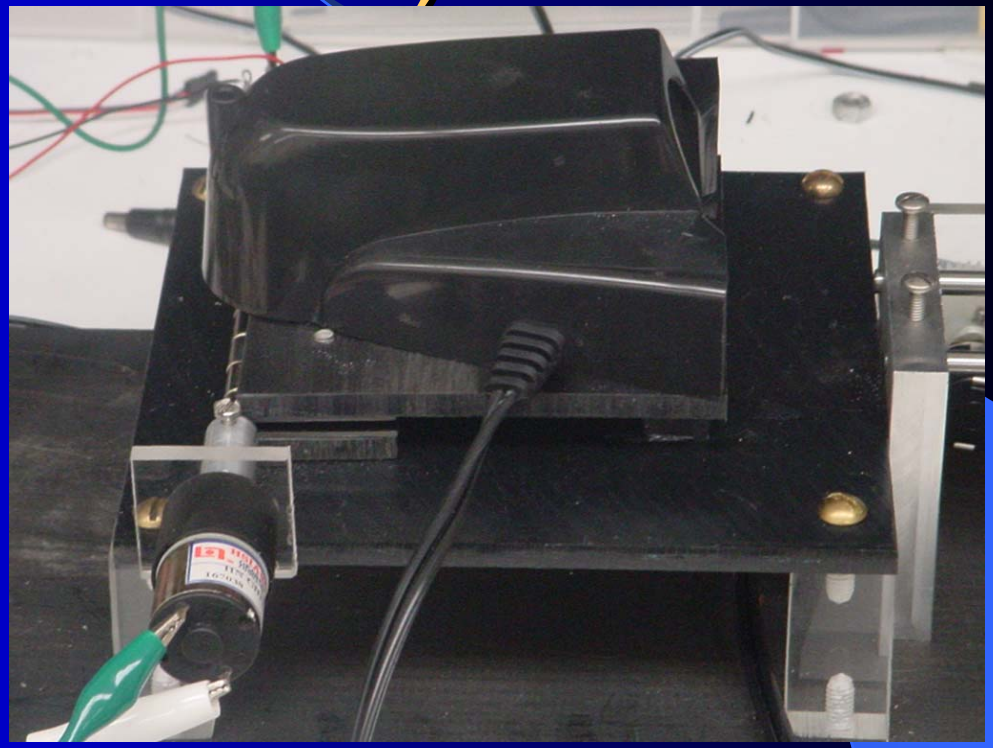
EQUIPMENT USED (LAUNCHER)

LAUNCHER

- A CONVERTED WILSON PUTTING PAL.
- USES A SOLENOID TO PULL BACK METAL BAR ONTO A SPRING.
- WHEN CURRENT IS STOPPED, SPRING PROPELS THE METAL BAR AND GOLF BALL IS LAUNCHED.

EQUIPMENT USED (PLATFORM)

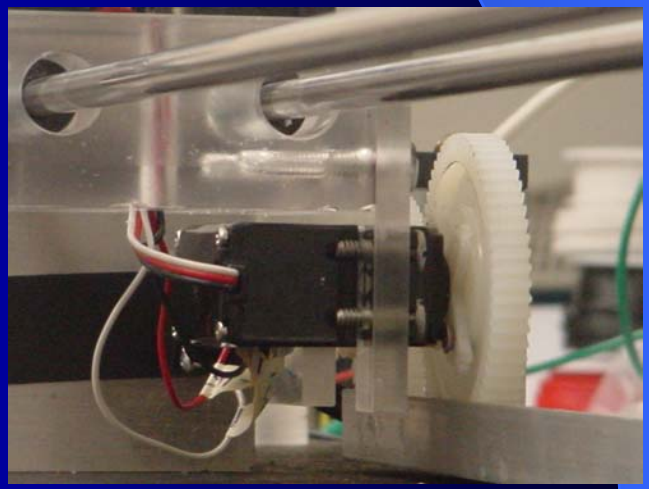
- A PLATFORM WAS BUILT TO PLACE THE LAUNCHER ON.
- THIS PLATFORM WAS POWERED BY A MOTOR TO RAISE THE LAUNCHER TO DIFFERENT ANGLES



EQUIPMENT USED (CATCHER)

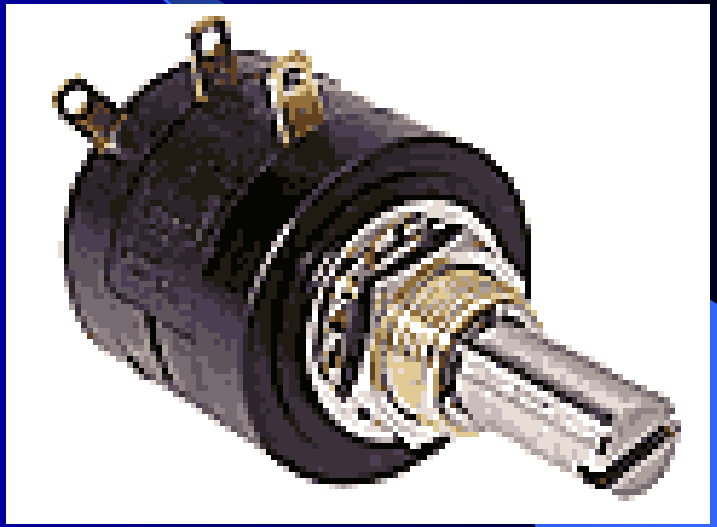
- A TRACK WAS BUILT (BY ALESSANDRO BETTI) SO THAT A LUCITE BLOCK WOULD SLIDE ALONG TWO METAL RODS.

- THE LUCITE BLOCK (CATCHER) WAS DRIVEN BY A SERVO MOTOR RIDING ON TOP OF A SPUR GEAR RACK.



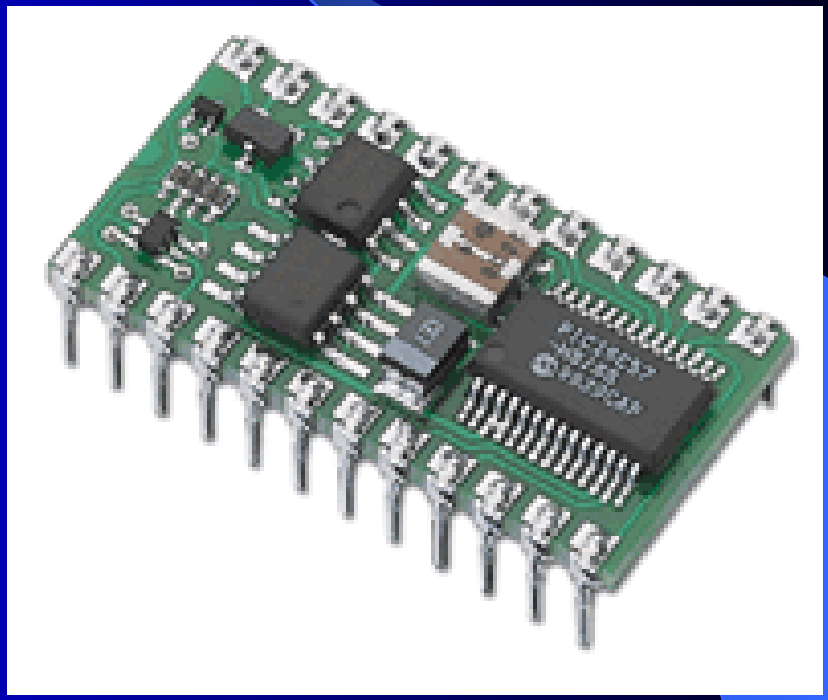
CONTROL MECHANISMS

- THE DISTANCE THAT THE CATCHER HAD TO MOVE FROM THE LAUNCHER AND THE ANGLE OF THE PLATFORM WAS DETERMINED USING A POTENTIOMETER.
- A POTENTIOMETER CHANGES RESISTANCE A DN CAN BE USED TO MEASURE DISTANCE.

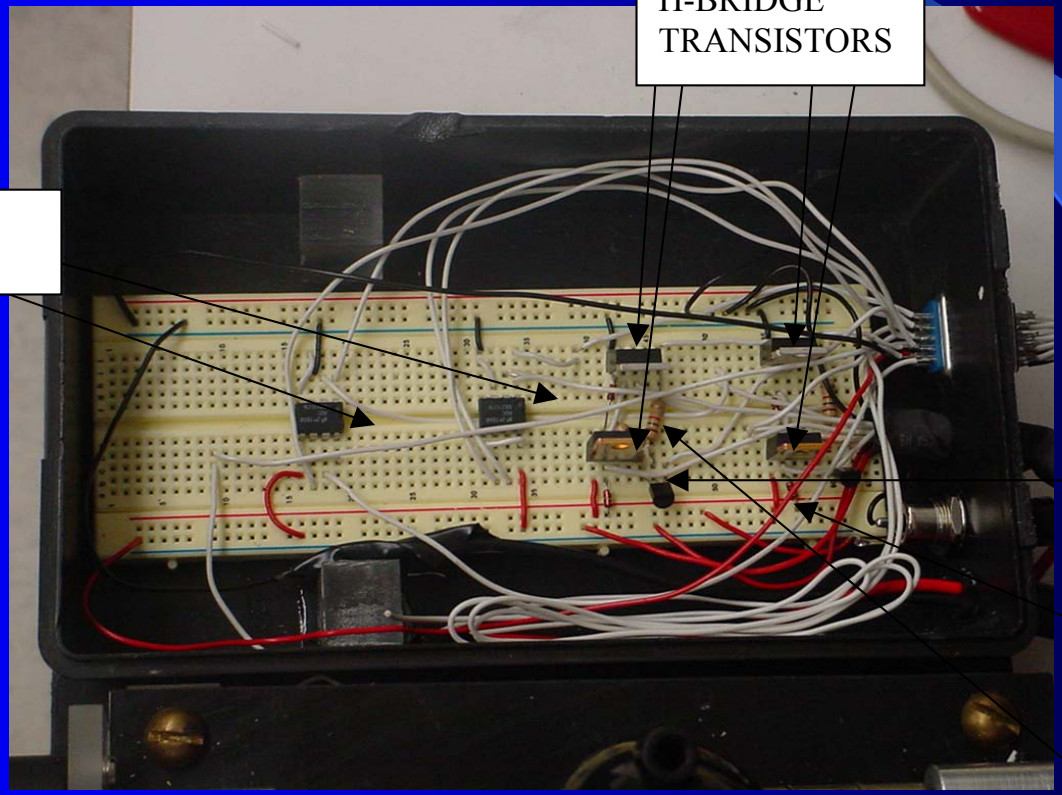


BASIC STAMP

- ALLOWS UP TO 16 INPUT AND OUTPUT PINS
- PERFORMS BASIC MATHEMATICAL CALCULATIONS
- POWERED BY THE P-BASIC SOFTWARE PROGRAM.



BREADBOARD COMPONENTS



SOLID STATE RELAY

- IN ORDER TO CONTROL THE MOMENT WHEN THE BALL IS LAUNCHED, A SOLD STATE RELAY WAS CONSTRUCTED.
- IT IS A SWITCH THAT ALLOWS CURRENT TO FLOW WHEN TURNED ON.

EXPERIMENT

- STUDENTS CHOOSE AN ANGLE BETWEEN 20 AND 65 DEGREES.
- "LAUNCHER" IS ELEVATED TO CORRECT ANGLE.
- BS2 CALCULATES CORRECT RANGE AND SENDS THE "CATCHER" TO THAT POSITION.
- WHEN THE STUDENT PRESSES 1, THE BALL IS LAUNCHED TOWARDS THE CATCHER.

RESULTS

- It was determined that the projectile launcher was accurate for angles from 20 to 30 degrees. When tested at these angles the ball constantly hit the catcher.
- At high angles, the motor was unable to produce the velocity (3 meters/second), required to propel the golf ball.
- We changed the formula so that the distance traveled by the catcher was reduced by an addition to the formula (the angle of the launcher minus twenty five). After further testing it was determined that the apparatus was now accurate between the angles of 20 and 65 degrees.

UNCERTAINTY ANALYSIS

- One unavoidable error in this experiment is due to the limitations of the BS2. The BS2 is unable to make floating point calculations, such as including the decimal point placement in a calculated number. This caused number to be rounded off at unacceptable limits.
- Since the voltage applied to the solenoid can vary in small amounts, the initial velocity of the golf ball will have a range of values.
- When the platform is raised to the desired angle, the hinge is unable to hold that angle exactly due to the mass of the platform, golf ball and launcher.

PROJECT COSTS

ITEM	SUPPLIER	PART NUMBER	UNIT COST	QUANTITY	TOTAL
Ping Pong Balls	Sports Authority	N/A	1.99	1	1.99
Foam Golf Balls	Sports Authority	N/A	2.99	1	2.99
Al Angle 48"	Home Depot	N/A	3.35	1	3.35
Putting Pal	Sports Authority	N/A	12.99	1	12.99
14.5 deg Spur Gear, 32 pitch, 52 teeth	McMaster	57655K48	4.09	1	4.09
14.5 deg Spur Gear Rack, 32 pitch,	McMaster	57655K62	4.78	4	19.12
Self Aligning Ball Bearings 1/4 ID	McMaster	6489K61	14.83	2	29.66
14.5 deg Spur Gear, 32 pitch, 62 teeth	McMaster	57655K49	6.27	1	6.27
Hardened Steel Shaft 48" x 1/4"	McMaster	6061K71	22.66	2	45.32
Analog-Digital Converter (ADC0831)	Parallax	ADC0831	6	2	12
TIP 42 Transistor (PNP)	Radio Shack	276-2027	1.49	2	2.98
1K Ohm Resistors	Parallax	150-01020	0.15	4	0.6
Zener Diodes	Parallax	1N4002	0.5	4	2.00
NPN Transistor	Radio Shack	2N2222	0.69	2	1.38
NPN Transistor	Radio Shack	TIP120	1.49	2	2.98
Futaba S148 Servo Motor	Parallax	S148	12	1	12.00
DC Motor	Jameco	N/A	21.95	1	21.95
10 Turn (10K) Potentiometer	Digikey	3590	13.38	1	13.38
100 K Potentiometer	Digikey	91	9.02	1	9.02
Wood (1x10x60)	Sids Hardware	N/A	7.99	1	7.99
				Total	**212.06**

SUGGESTED PROJECTS

- 1. Determine the relationship between the angle of release and launch velocity.
- 2. Use sensors to verify the maximum height of the golf ball at different angles.
- 3. Account for discrepancy between launch height and catcher platform.