First-class lever

A DEMONSTRATION PROJECT

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Introduction

Simple machines is one of the middle school lessons that could hardly be grasped by the students. Teaching mechanical advantage and efficiency , for example, could be very challenging.

This project aims to meet the needs of the visual and kinesthetic students and enhancing the understanding of the logical learners.

This activity shows the concept that the input force is greater when it is closer to the pivot point that when the input is farther from the pivot point.

The machine is given a fixed weight at one end and then set the machine to start releasing sand to the bucket so the ultrasonic sensor on top of the tube containing the sand can measure the initial and final height of sand. From this, the force is calculated using the formula:

$$F = ma$$

From $D = m/v$ $\qquad$ thus $m = DV$

by substitution, we get

$$F = DV (9.8 \text{ m/sec}^2) \qquad \textbf{Where:}$$

$$= D (\pi r^2 a) \Delta H \qquad\qquad D = \text{density}$$

$$F = \Delta H ** 61791 \text{ N} \qquad\qquad \pi = \text{pie}$$

$\qquad\qquad\qquad\qquad\qquad\qquad$ R = radius

$\qquad\qquad\qquad\qquad\qquad\qquad$ A = acceleration

$\qquad\qquad\qquad\qquad\qquad\qquad$ ΔH = change in height

BACKGROUND

Simple Machines

First Class Lever

A **lever** is any rigid rod or plank that pivots, or rotates, about a point. The point about which the lever pivots is called a fulcrum.

Levers are one of the basic tools that were probably used in prehistoric times. Levers were first described about 260 BC by the ancient Greek mathematician Archimedes (287-212 BC).

A lever is a simple machine that makes work easier for use; it involves moving a load around a pivot using a force. Many of our basic tools use levers, including scissors , pliers , hammer claws ,and nut crackers.

The mechanical advantage of a lever changes as the position of the fulcrum changes and it increases as the fulcrum is moved closer to the output force. It is calculated by dividing the distance from the fulcrum to the input force by the distance from the fulcrum to the output force. When the fulcrum is closer to the output force than the input force, the mechanical advantage is greater than one.

In a Type 1 Lever, the pivot (fulcrum) is between the effort and the load
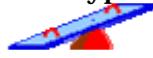
. In an off-center type one lever , the load is larger than the effort, but

is moved through a smaller distance   .

Standards

This project meets the New York City Physical Science Performance Standards

Physical Science Concepts
S1b The students provides evidence that demonstrates understanding of motion and forces, such as inertia and the net effects of balanced and unbalanced forces;

Scientific Connections and Applications
S4a
Big ideas and unifying concepts, such as order and organization; models, form, and function; change and constancy; and cause and effect
S4d
Impact of technology such as constraints and trade-offs, feedback, benefit; benefits and risks; and problems and solutions

Scientific Thinking
S5a
Frames questions to distinguish cause and effect; and identifies or controls variables
S5e
Identifies problems, propose and implements solutions; and evaluates the accuracy, design, and outcomes of investigations
S5f
Works individually and in teams to collect and share information and ideas

Scientific Tools and Technology
S6a
Uses technology and tools to observe and measure objects, organisms, and phenomena, directly and indirectly, and remotely
S6c
Collects and analyzes data using concepts and techniques in Mathematics Standard 4.
S6e
Recognizes sources of bias and data

Materials:
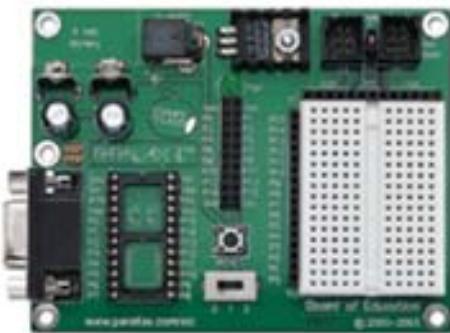
Board of Education (BOE)

The BOE is a programming board which holds the Basic Stamp. It also allows user to control LEDs, a potentiometer, motors and even the solenoids in this project.

Basic Stamp 2 (BS2)

The Basic Stamp is a microcontroller which uses PBasic programming language and is able to interpret input signals, and provide output signals.

LCD

The Parallax Serial LCD (non-backlit) provides a very functional, low-cost LCD that can be easily controlled by a BASIC Stamp. In our experiment, it was used to record the initial and final height of the sand and the force exerted by the sand to push the plank downwards.

Servo motor

Servos may be controlled directly from a BASIC Stamp I/O pin by using the PULSOUT command. Servos may be easily modified for continuous rotation. In our experiment, it was used to open and close the opening of the tank

12 volts DC motor geared down

Provides the work to raise or lower the incline. The motor is geared down to increase torque and decrease angular velocity.
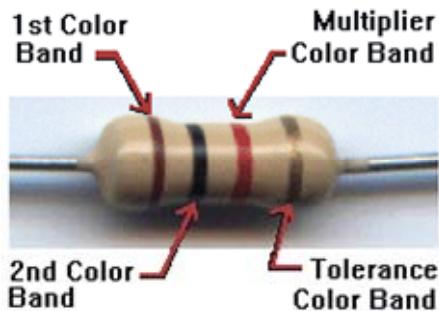
Resistors

These are very small devices which are used to control current in an electric circuit by providing resistance.

LED

  This type of lighting is most commonly used to illuminate signs, signals and displays but is rapidly evolving to provide light for general illumination. LEDs functioned as signals for starting and ending the activity.

Ping ultrasonic sensor

A sensor that determines its distance from another object. It detected the amount of sand the was released down the bucket.

15 pin D Converter

This is used to provide a convenient connection between the project's circuit board and the Basic Stamp.

Piezo speaker

This small Piezo speaker can be connected directly to your microcontrollers I/O pin to make sounds. There is a small 0.05" spaced plug on the end. This speaker does not require an amplifier to be connected to any TTL or CMOS output.

Momentary Push Button (SPST)

The push button provides a momentary electrical connection .   Pressing the buttons started the parts of the activity.

Sand

Sand is used in our set-up as a timer. As it flows down the tube, the ultrasonic sensor measures the force.

Computer

The computer contains the program that runs the steps in a task assigned it.
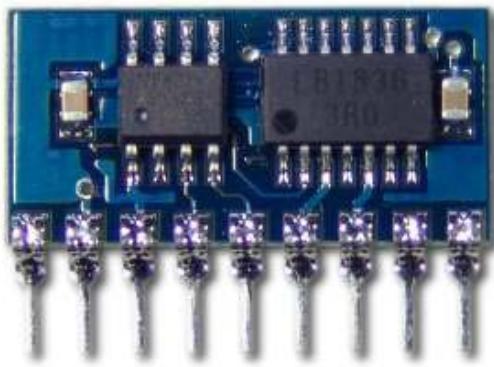
Micro Dual Serial Motor Controller

This controls the motor, functioning as an H-Bridge

Program Code

```
' Group 9
' {$STAMP BS2}
' {$PBASIC 2.5}

' -----[ Declarations ]---------------------------------------------

        ' Piezo Speaker
counter       VAR    Word
force         VAR    Word
time          VAR    Word
HeightMax     VAR    Word
HeightMax1    CON    4
HeightMax2    CON    8
HeightMax3    CON    12
CmConstant    CON    2260
forceConstant CON    61791
cmDistance    VAR    Word
cmDistance1   VAR    Word
cmDistanceInitial VAR  Word
cmDistanceFinal VAR    Word
countertrial VAR Word

'Declarations for Ultrasonic


lcdPin              CON     11
motorPin            CON     5
motorPinReset       CON     6
ultrasonicPinBot    CON     8
ultrasonicPinTop    CON     9
servoPin            CON     10

Main:
DO
HIGH motorPin
LOW motorPinReset
HIGH motorPinReset
PAUSE 100
IF (IN0 = 1) THEN  'Move right

 'Move the fulcrum to the second position
  DO WHILE (IN0=1)
  SEROUT motorPin, 84, [$80,0,0,127]
```

```
   PAUSE 20
   LOOP
ELSEIF (IN1=1) THEN   'Move left

 'Move the fulcrum to the second position
   DO WHILE (IN1=1)
   SEROUT motorPin, 84, [$80,0,1,127]
   PAUSE 20
   LOOP
ENDIF
IF (IN2 = 1) THEN   'Run regular program

'Turn Yellow Light On
LOW 3
HIGH 7
PAUSE 500


   PAUSE 200
   SEROUT lcdPin, 32, [22, 12]
   PAUSE 5


GOSUB ultrasonicTop
cmDistanceInitial = cmDistance1


'Turn Servo Motor CounterClockwise to open trap door releasing sand.

FOR counter = 1 TO 20
PULSOUT servoPin, 300
PAUSE 20
NEXT

'Read LCD Ultrasound (bottom) for a max distance

 DO


   'Send Display to LCD
   PULSOUT ultrasonicPinBot, 5
   PULSIN ultrasonicPinBot, 1, time
   cmDistance = (cmConstant ** time)
   DEBUG DEC cmDistance, CR
   PAUSE 500
```

```
   IF (countertrial = 0) THEN
   HeightMax = HeightMax1
   ELSEIF (countertrial = 1) THEN
   HeightMax = HeightMax2
   ELSEIF (countertrial = 2) THEN
   HeightMax = HeightMax3
   ENDIF
LOOP UNTIL (cmDistance > HeightMax)

' Turn Servo motor clockwise to close trap door
FOR counter = 1 TO 20
    PULSOUT servoPin, 200
    PAUSE 10
NEXT

'Make a Sound through speaker
FREQOUT 4,1000,1568
' Turn Yellow Light Off
LOW 7
'Turn Red Light On
HIGH 3
PAUSE 2000

'Ultrasonic on top measures height used to measure the Force


 'Send Display to LCD
 GOSUB ultrasonicTop
 PAUSE 500
 cmDistanceFinal = cmDistance1
'Calculates force
 force = (cmDistanceFinal - cmDistanceInitial) ** forceConstant


'Display Height and Force to LCD
 SEROUT lcdPin, 32, [12]
 PAUSE 5
 SEROUT lcdPin, 32, [DEC cmDistanceInitial, " cm    ", DEC cmDistanceFinal, " cm"]
 SEROUT lcdPin, 32, [148, DEC force, " N   "]
 countertrial=countertrial+1



ENDIF
LOOP
```

ultrasonicTop:

PULSOUT ultrasonicPinTop, 10
PULSIN ultrasonicPinTop, 1, time
SEROUT lcdPin, 32, [12]
cmDistance1 = (cmConstant ** time)
SEROUT lcdPin, 32, [DEC3 cmDistance1, " cm"]
PAUSE 500

RETURN

Schematic diagrams
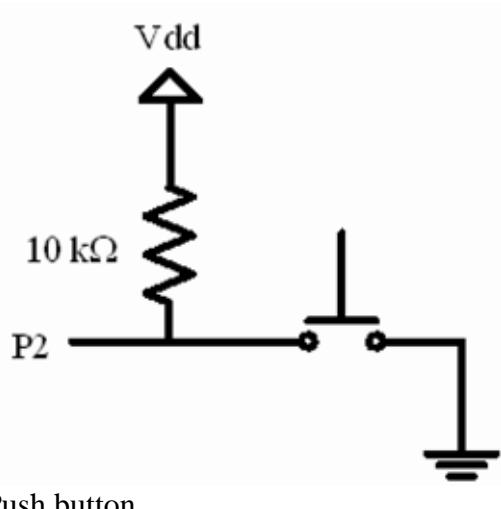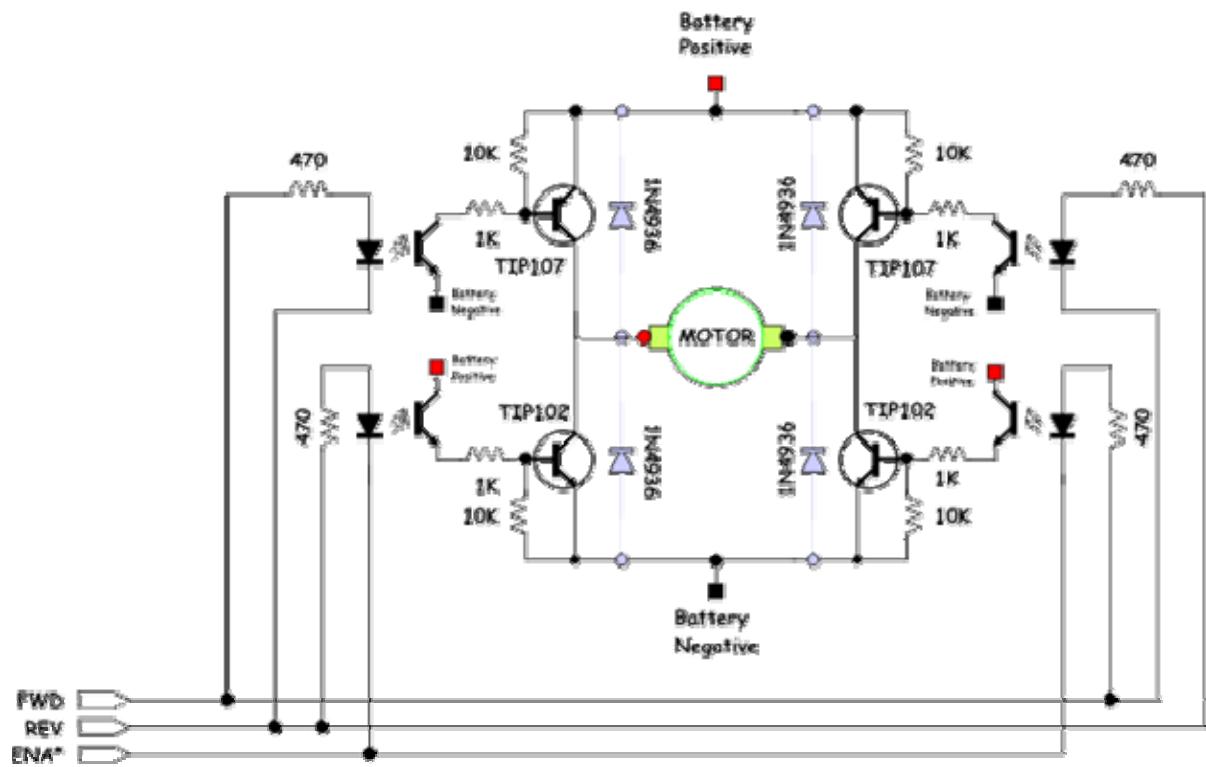
Push button

H-Bridge
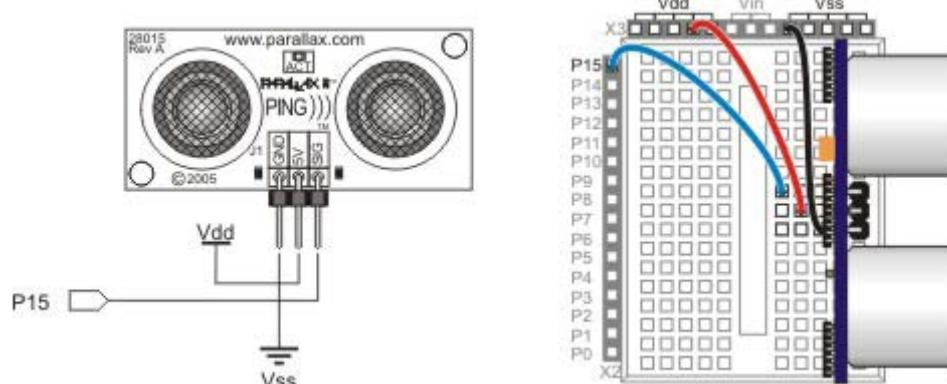
**Ping ultrasonic**

Wiring setup
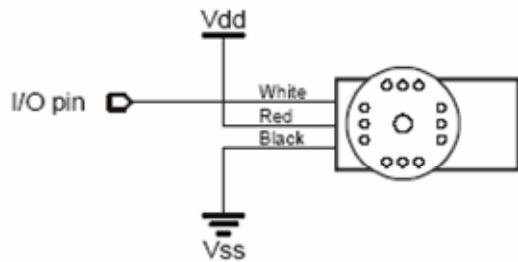
Servo motor
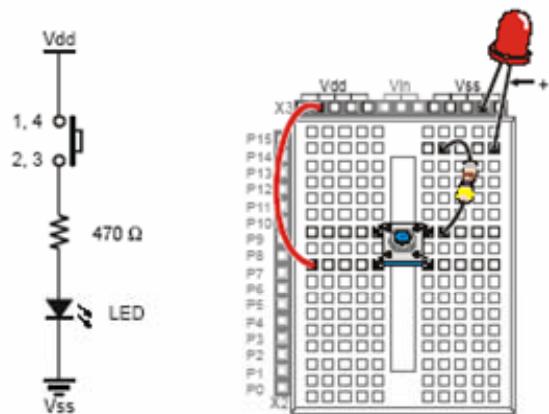
Figure 3-3
Pushbutton Test Circuit
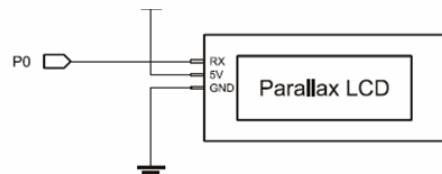
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Mr. Alex Betti

Edheads - Simple Machines Online

Acknowledgement: