Paperstack
International

T.P.S. REPORT

COVER SHEET

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Device/Program Type: Stapler Game for ME 218A

Vendor: Stanford University

Project Start Date: 11-05-2007

Project Completion Date: 12-07-2007

CONFIDENTIAL

PURPOSE OF REPORT

This report provides detailed information on the mechanical, electronic and software related elements of the Stapler Game. The information should be enough to allow someone with knowledge of mechatronics to be able to replicate the game. However, this game is quite complicated so beware that replicating it will be a daunting task.

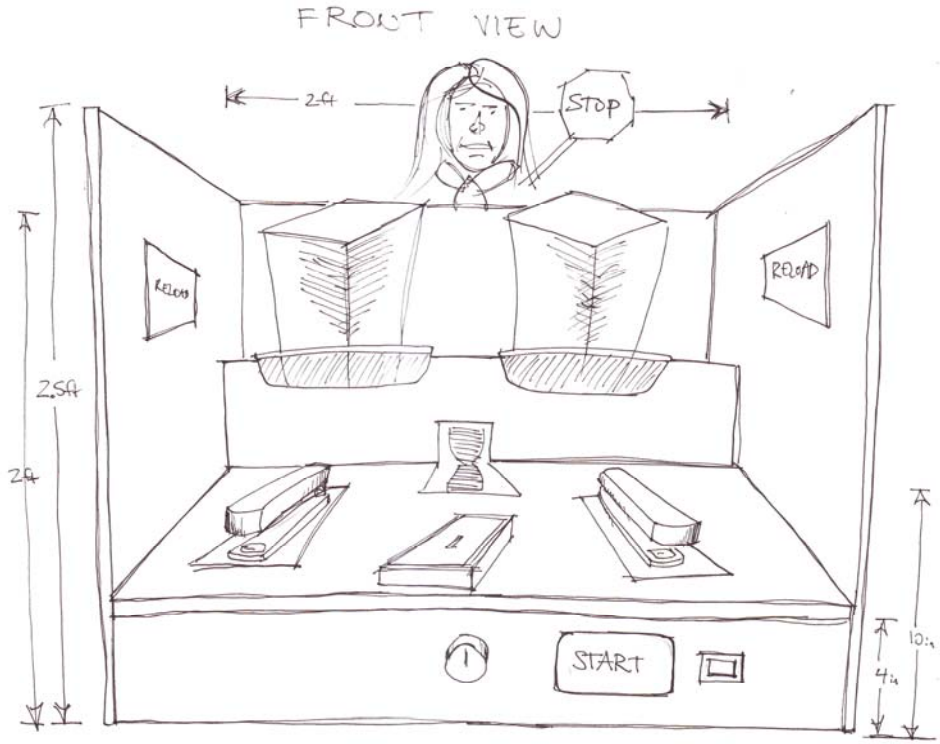
The pages that follow are primarily concerned with the technical information of the game. For a description of the game and how one plays it, please see the website.

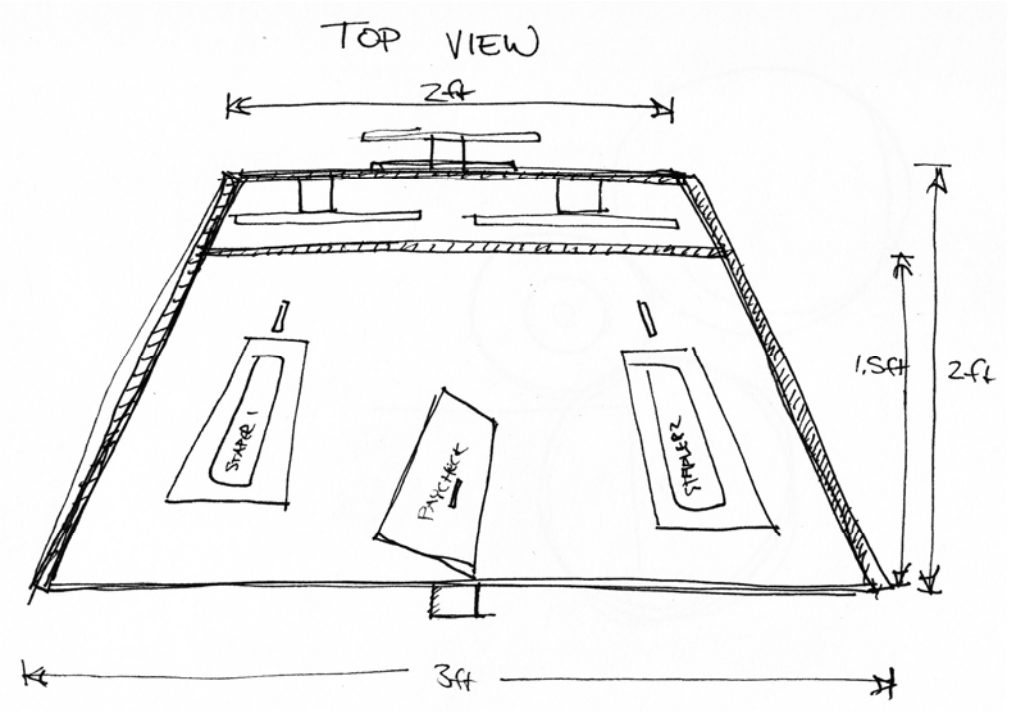
MECHANICS

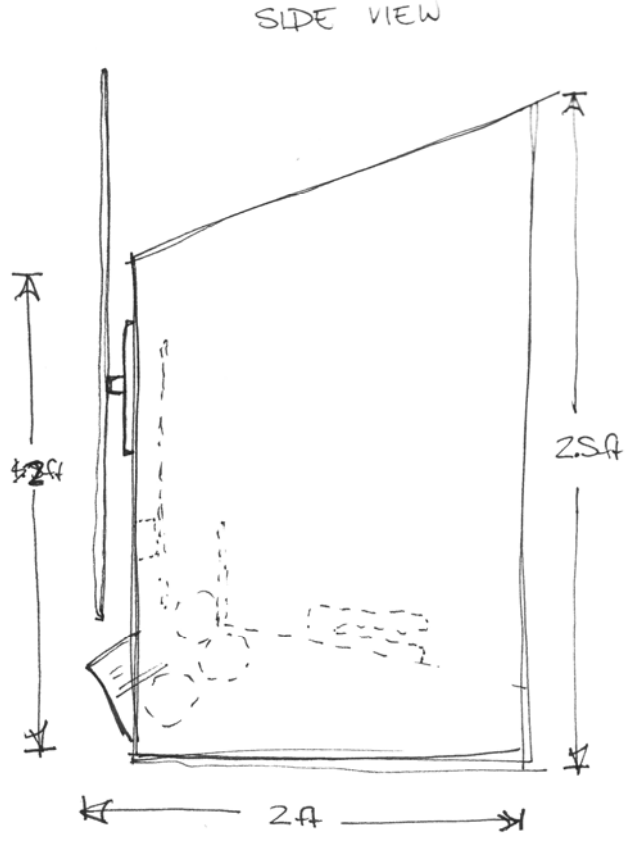
CHASIS

Every good penny arcade game starts with a solid, well built chassis as a foundation. The Stapler Game features such a chassis. This chassis is not only strong but is also aesthetically interesting. The chassis is intended to look like an office cubical with exaggerated perspective. When one approaches the Stapler Game, they feel as though they have just sat down at a stereotypical desk in a stereotypical cubical.

The chassis was constructed primarily our of masonite fiberboard and plywood, which was cut both using a laser cutter and hand tools. The technical drawings below show the rough size of the chassis and the layout of the various components on the chassis.

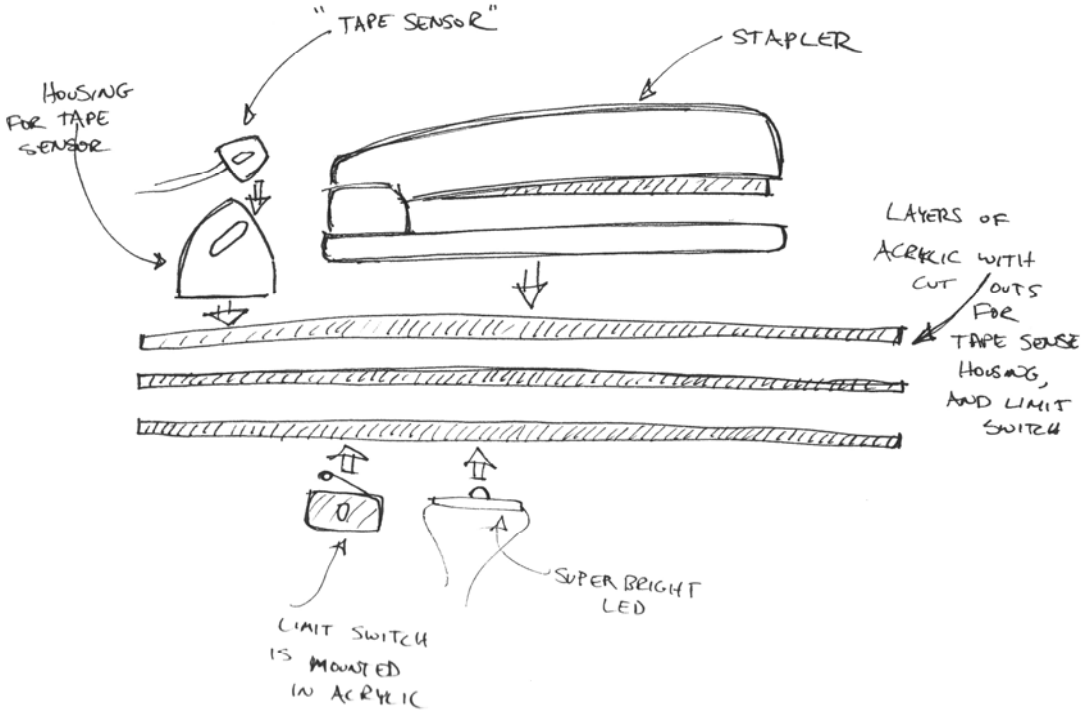



TOP VIEW
2ft
1.5ft
2ft
3ft
STAPLER
PAYCHECK
STAPLER


SIDE VIEW
2ft
2.5ft
2ft

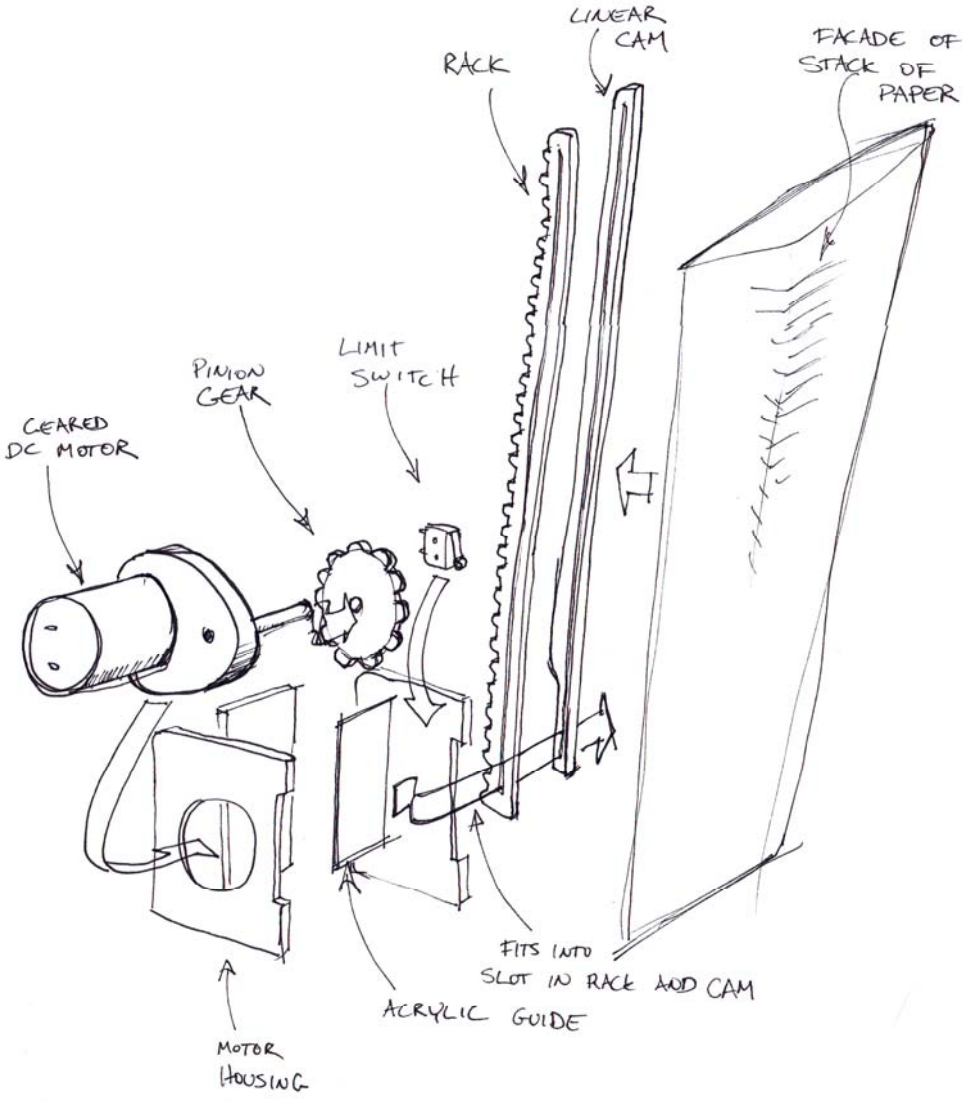
STAPLERS

The primary user input in the game is the staplers. The staplers are unmodified Swingline staplers. A limit switch is mounted on the underside of each stapler to sense when the staplers are pressed. There are also tape sensors mounted behind the staplers which can sense when the stapler has been opened. A single LED is mounted below each stapler to alert the player they should be stapling during play. All of these components are mounted to a laser cut stack of acrylic sheets. These sheets have mounts for all of the various components and the staplers. They are also transparent, so the acrylic appears to glow when the LED is turned on. The drawing below shows how all of the components fit together.



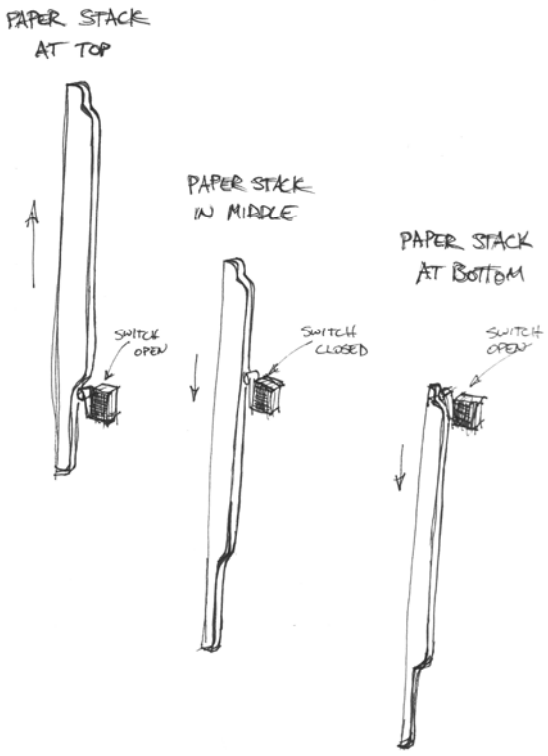
PAPERSTACKS

The “stacks of paper” at the rear of the desk are the main indication to the player of how much progress that have made in the game. Although it may appear that that there are actual stacks of paper, there are not. As shown in the drawings below, the “stacks of paper” are just cardstock facades mounted on to a rack and pinion mechanism that makes them rise and fall.

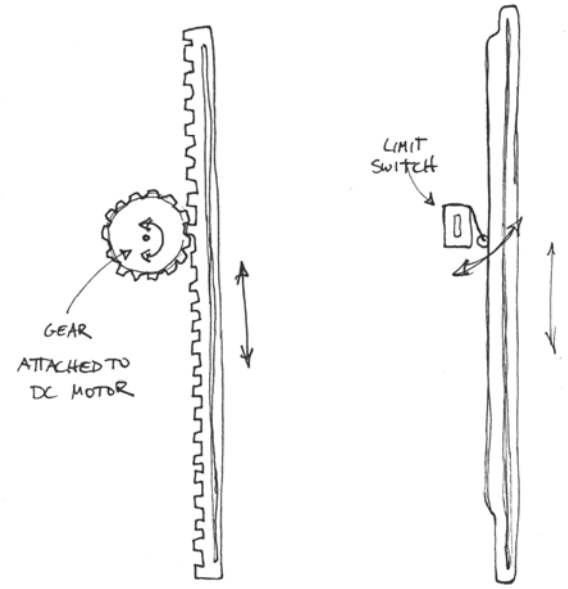


There is a linear cam mechanism which actuates a limit switch when the stack is at either its top or bottom limit.

Linear Cam Functionality

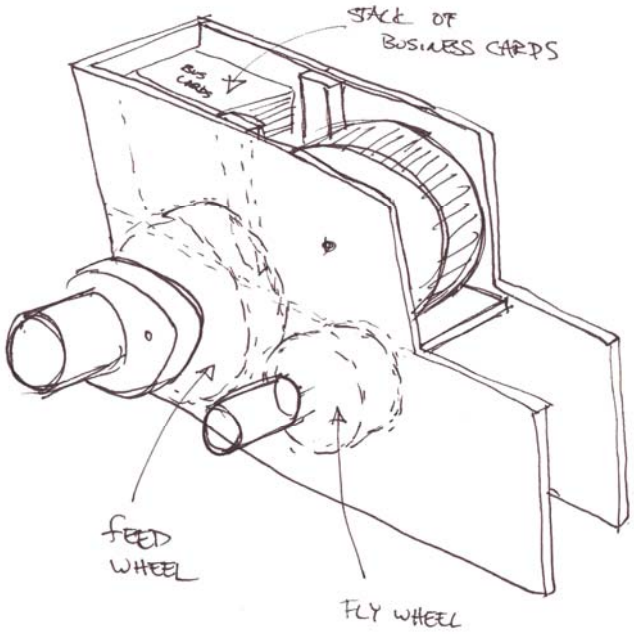


Rack and Pinion and Linear Cam

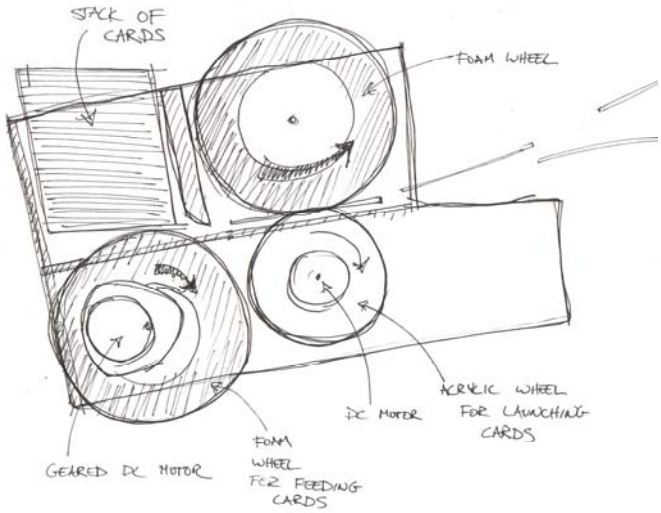


BUSINESS CARD DISPENSER

At the end of the game, the business card dispenses business cards to the players as a prize. The dispenser uses two DC motors to deliver the cards. One of the motors powers a foam wheel which feeds the cards from a caddy to the next stage of the dispenser. The other motor powers and acrylic wheel which functions as a flywheel to launch the cards up into the air.

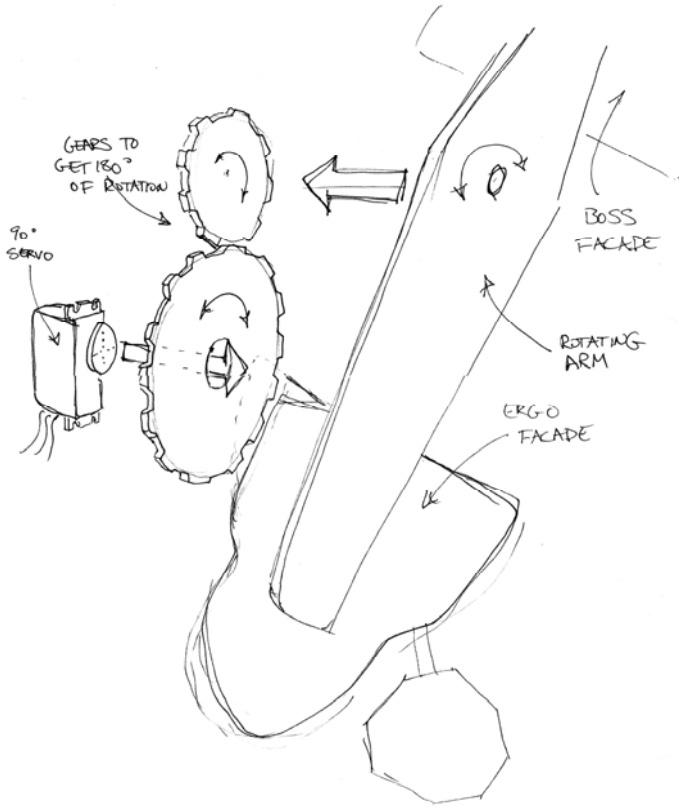


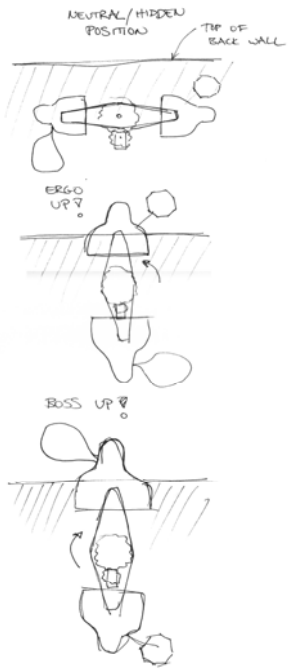
Side View



POPUPS (BOSS AND ERGONOMIST)

During game play, the players are visited by both their boss and their ergonomist. These “visits” are facilitated by a servo motor which rotates an arm that has an image of a boss on one side and an image of an ergonomist on the other. The servo only has a rotational range of 90 degrees, yet 180 degrees are needed to account for the three possible displays: the boss, the ergonomist or nothing. There are laser cut gears to gear up the servo so that there is a full 180 degrees of rotation.

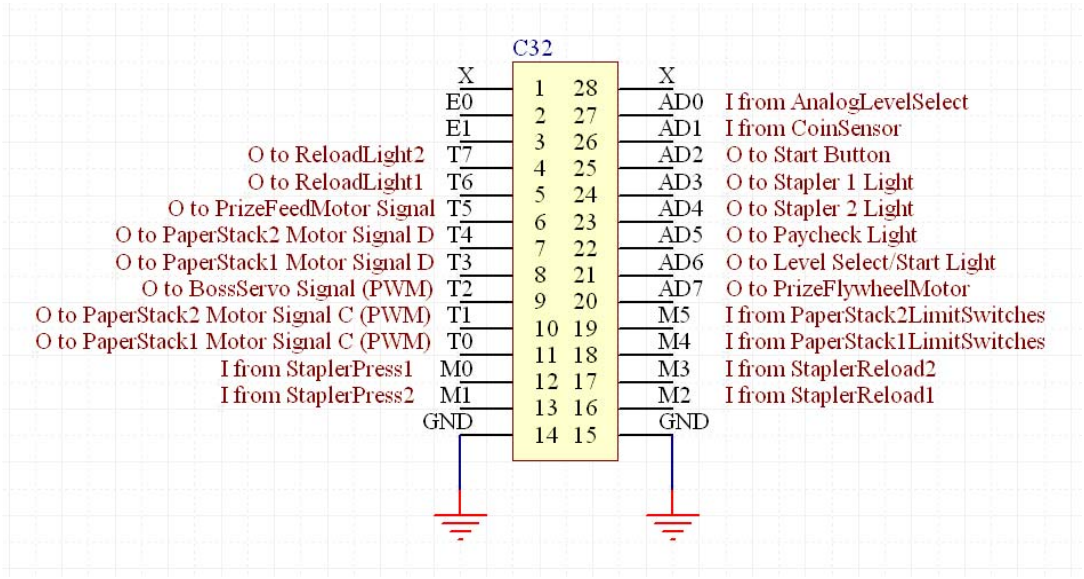




ELECTRONICS

OVERVIEW

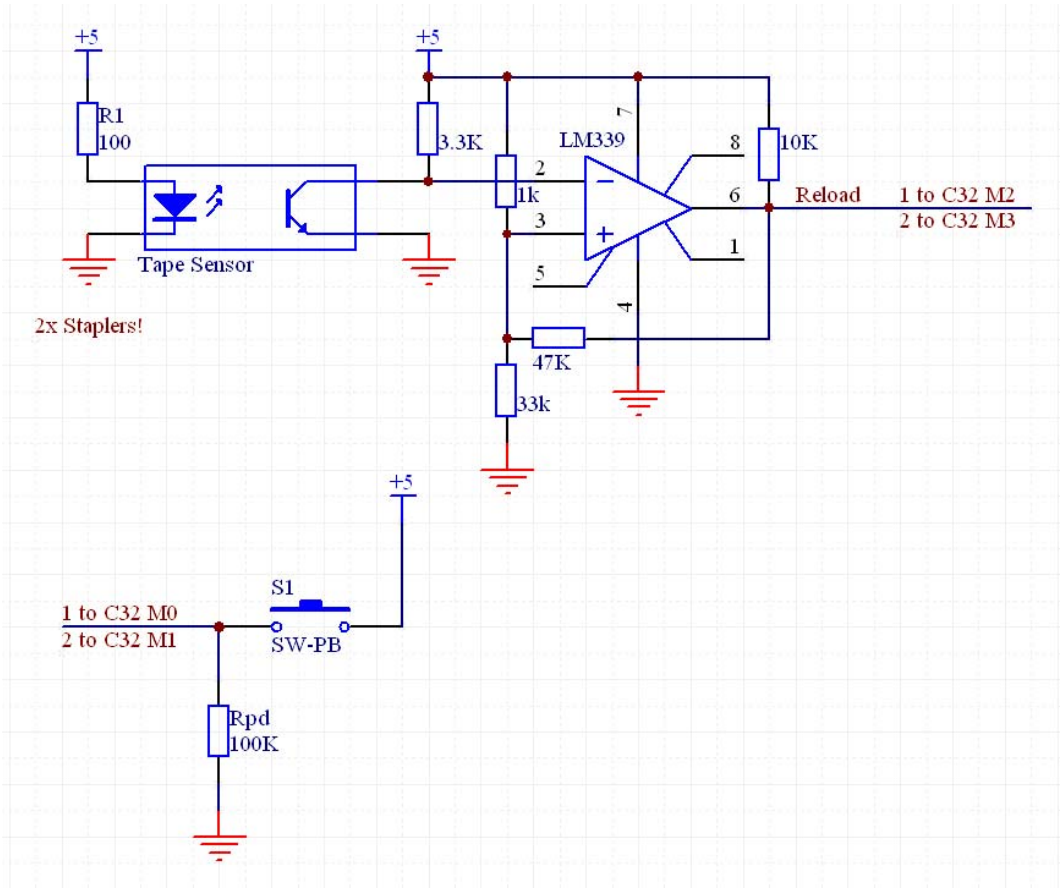
The Stapler Game uses all of the I/O pins on the C32 microcontroller. The diagram below shows what each pin on the C32 is used for. As the diagram shows, the pins feed into a variety of different circuits which have a variety of functions.



STAPLERS

Each stapler is equipped with a limit switch (for sensing when the stapler has been pressed) and a tape sensor (for sensing when the stapler has been opened). The tape sensor is a packaged device that contains an infrared LED and a phototransistor. On the detection side, the circuit features a comparator with hysteresis implemented to get a clean digital signal. The hysteresis was adjusted so that the output to the C32 changed states when the stapler was within 1/8 inch of the tape sensor.

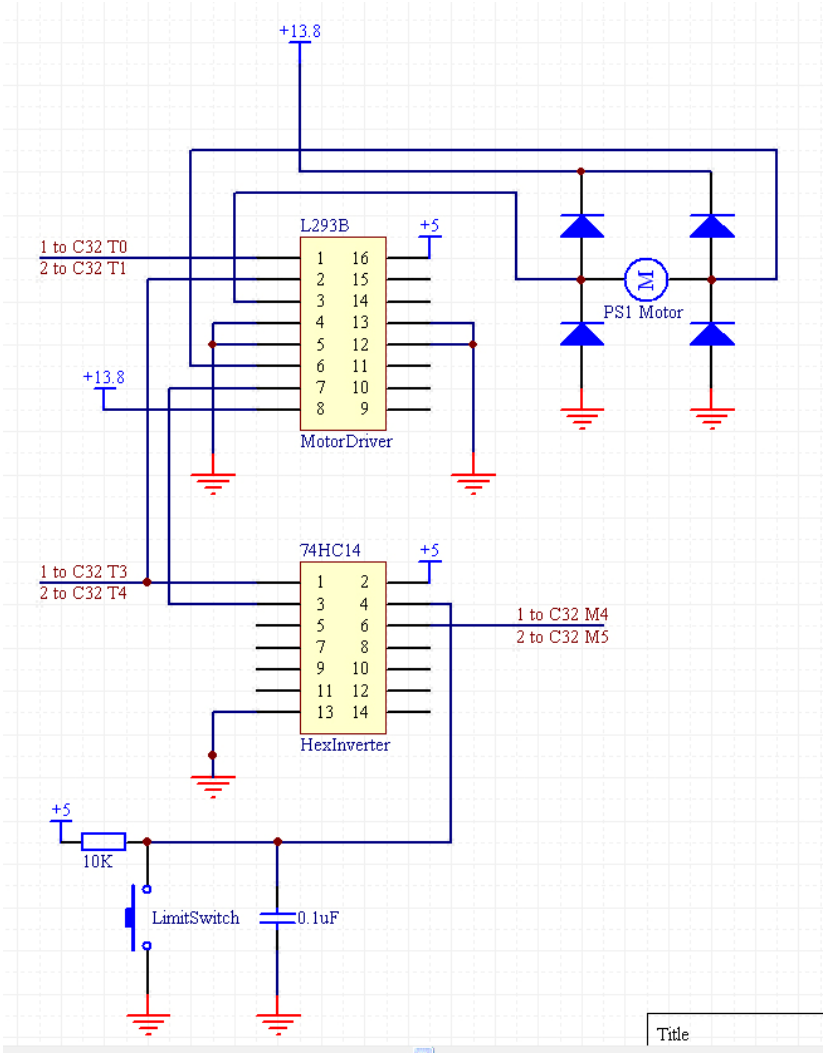
The limit switch circuit has a pull down resistor so that the output to the C32 is pulled down to 0 V when the stapler is no depressed. However, when the stapler is depressed the limit switch is closed and the output changes state.



PAPERSTACKS

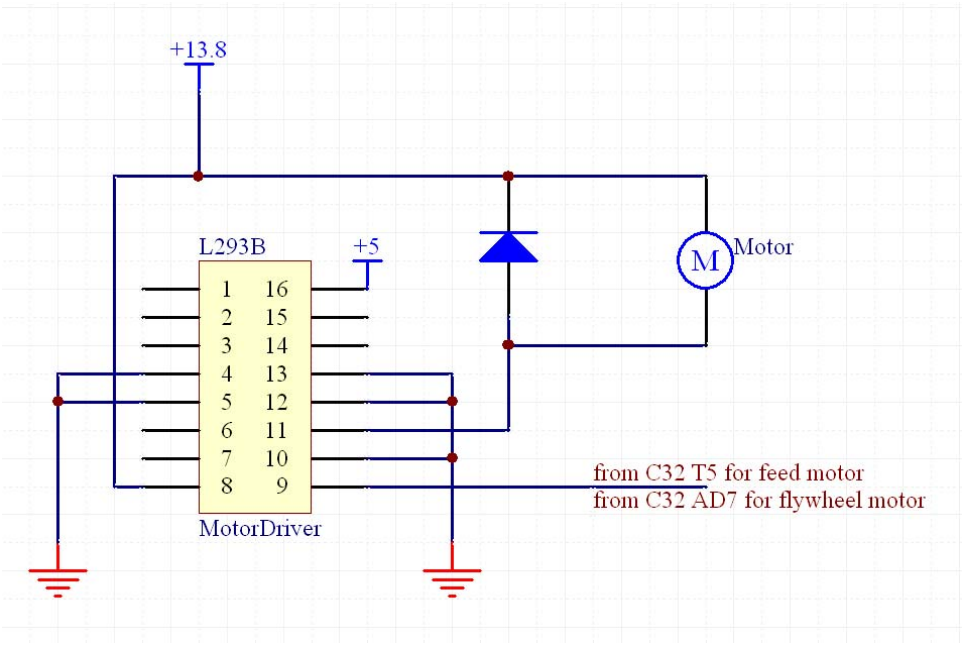
The paperstacks are raised and lowered using a geared DC motor. The motor is controlled using a motor driver chip (LM293B) in an H-Bridge configuration with protection diodes. One output from the C32 is used as a PWM signal to the driver and another output is used to control the direction of the motor. A hex inverter is used to invert the direction signal so that a single output from the C32 can be used to control the two inputs to the motor driver.

A limit switch is used to detect when a stack has reached either the top or bottom of its travel. A debouncing circuit (consisting of low-pass filter and hex inverter) is used to eliminate noise when the switch is actuated.



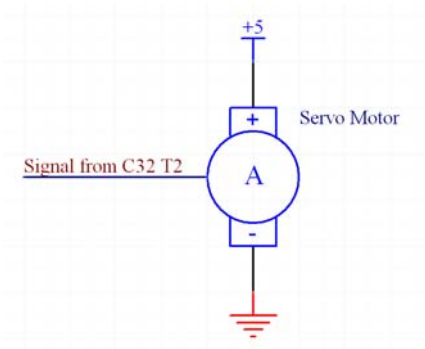
PRIZE MOTORS

The motors used to administer the business cards are controlled using a motor driver (LM293B) and a half H-bridge circuit with diode protection. A half H-bridge was used because the motors only spin one direction.



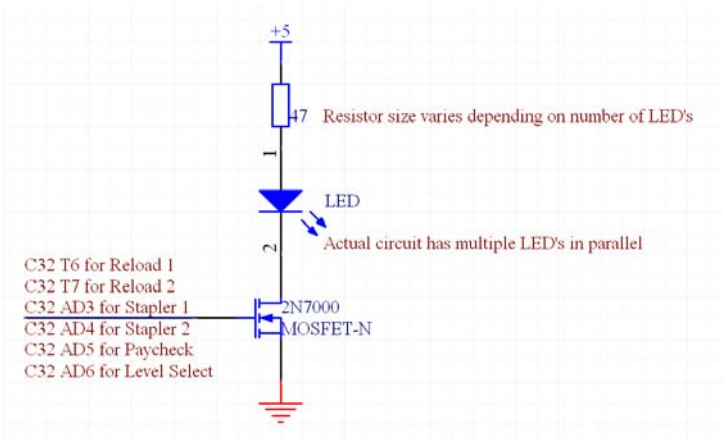
BOSS/ERGO SERVO

The servo which raises and lowers the boss and ergonomist is controlled by a very simple circuit. The servo is connected to 5 V and ground and is given a PWM signal directly from the C32 which sets the position of the servo.



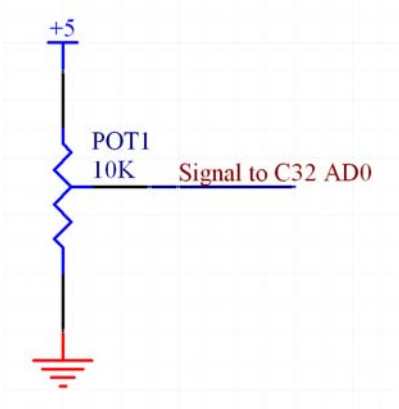
LED’s

The game contains many LED’s to alert the players of what is going on in the game. Each of the LED circuits are controlled by an n-channel mosfet (2N7000) with a signal from the C32 connected directly to the gate of the mosfet. Each circuit has a different number of LED’s so each circuit has a different size resistor to limit the current through the LED’s.



LEVEL SELECT

A potentiometer is used to allow the players to select the difficulty of the game. The signal from the potentiometer is connected to an analog-to-digital input on the C32, so the position of the potentiometer can be sensed.



SOFTWARE

Below is the pseudo code for the software that runs the game. The actual code is written in C and is attached as Appendix A.

Play.c – Main Event Checker Module

```
Main() {
    Perform main initialization sequence
    Initialize reset once
    Run main event checker in an endless loop
}

Main Event Checker (runs continuously throughout the game, handles all
game states) {
      Check for interrupts and refresh continuous state variables
      Check which game stage we're in:
      {
      If we're in RESET mode:
        If mechanical elements are in place and no longer moving, you're
        done resetting. Wait for coin!
            Initialize waitcoin
            Turn off all LEDs
            Go to waitcoin stage

      If we're in WAITCOIN mode:
        When a coin is sensed, initialize waitstart
        Go to waitstart stage

      If we're in WAITSTART mode:
        check the level
        When the start button is pressed, initialize pregame
        Go to the pregame stage

      If we're in PREGAME mode:
        If all mechanical elements are done moving
        Initialize the game, go to game stage

      If we're in GAME mode:
        Check for winner. If there is one, end the game.

        Check which level we're on:

      if EASY:
        If player 1 has stapled
            Increment score
            Update paper stack 1 position
        If player 2 has stapled
            Increment score
            Update paper stack 2 position

      if MEDIUM:
        If player 1 has staples left
            if player 1 has stapled
                Increment score
                Update position of paper stack
        If they are out of staples, do nothing until they reload
            Illuminate the reload light only
            if player reloads
                Illuminate the stapler lights only
```

```
  If player 2 has staples left
      if player 2 has stapled
          Increment score
          Update position of paper stack
  If they are out of staples, do nothing until they reload
      Illuminate the reload light only
      if player reloads
          Illuminate the stapler lights only

If HARD:
  One of three scenarios:

1)    If it's past time for the ergonomist to show up and she
hasn't already come
      Set ergo flag high
      Start timer so we know when to put her away
      Pop her up!
      Set "gotcha" flags to zero for both players

2)    If ergo has already wreaked her havoc OR if she hasn't shown
up yet, we treat it like it's MEDIUM
  If player 1 has staples left
      if player 1 has stapled
          Increment score
          Update position of paper stack
  If they are out of staples, do nothing until they reload
      Illuminate the reload light only
      if player reloads
          Illuminate the stapler lights only

  If player 2 has staples left
      if player 2 has stapled
          Increment score
          Update position of paper stack
  If they are out of staples, do nothing until they reload
      Illuminate the reload light only
      if player reloads
          Illuminate the stapler lights only

3)    If ergo is present and is in the process of wreaking havoc
  If the grace period has expired, we can punish the players
      If player 1 has stapled
          If gotcha flag is low, they haven't been punished yet,
          so punish them! ha!
              Decrement score
              Move paper stack up
              blink their stapler!
              Gotcha flag goes high
      If player 2 has stapled
          If gotcha flag is low, they haven't been punished yet,
          so punish them! ha!
              Decrement score
              Move paper stack up
              blink their stapler!
              Gotcha flag goes high
      If ergo time has expired, is done wreaking havoc
          put the management away
          relight both staplers

if we're in POSTGAME mode:
      dispense the prize
      When the prize has been successfully dispensed, reset the
game!
      Go to reset stage
```

```
      }

RunChecks (handles checking of all continuously monitored states) {
    If reset button has been tripped
        Reset the game
        Game stage is now RESET
    Blink any LEDs that need blinking
    Stop any paper stacks that have hit their limit switches
}

Initialize main game (only run once at beginning of game) {
    Initialize timer
    Initialize PWM, set period to 20ms
    Initialize AD ports
    Set all M ports to inputs
    Set all T ports to outputs
    Start with all bits off
}

Initialize reset game stage {
    Set paper stacks to bottom position
    Set coin inserted flag to zero
    Turn off all LEDs
    Put boss + ergo away
}

Initialize waitcoin game stage {
    Illuminate paycheck slot only
}

Check for coin {
    Get current state of coin sensor
    Return a 1 if coin has been detected
}

Initialize waitstart stage {
    Illuminate start light only
}

Initialize pregame stage {
    Set both paper stacks to top position
    Set scores to zero
    Refill staplers
    Turn all lights off
}

Initialize game stage {
    Illuminate staplers only
    If difficulty is hard
        set ergo surprise timer
        set ergo presence flag low
}

Initialize postgame sequence {
    Set player with highest score to "winner"
    Flash their stapler
    Boss emerges
    Initialize prize dispenser
}

IsWinner (returns true if a player has won) {
    Determine if any player's score exceeds that of the winning score
for the level they're playing
    Return true if a player has won
```

```
}
```

Paper.c – Module to control paper stack movement + positioning

```
SetPopup (given a paper stack ID and position, moves the stack to that
position) {
      If it's already moving, do nothing
      If it's going to the minimum position:
            If it's already there, don't do anything
            Otherwise, plow down until you hit the limit switch
            Update the position array for that paper stack
      If it's going to the maximum position:
            If it's already there, don't do anything
            Otherwise, plow down until you hit the limit switch
            Update the position array for that paper stack
      Otherwise, if it's going somewhere in between the max and min
            If the final position is higher than where we are right now
                  Set motor direction to UP
                  Calculate how long to turn on the motor to reach
                  destination
            If the final position is lower than where we are right now
                  Set motor direction to down
                  Calculate how long to turn on the motor to reach
                  destination
            Turn on the motor for the calculated period of time
            Update paper position array
}

Check all popups for arrival (returns true if all paper stacks are done
moving) {
      If stack one and stack two are not moving, return true
}

Check popup for arrival (given a motor ID, tells us whether it's moving)
{
      If paper stack is moving
            If it has hit the limit switch
                  If direction is DOWN
                        Update paper position array to MIN
                  If direction is UP
                        Update paper position array to MAX
                  Stop the motor
            If the motor timer has expired
                  Stop the motor
      Return true
}

Calculate move duration (given incremental change in position, motor ID,
and direction, returns length of time motor should be turned on) {
      Calculate percentage of total range of motion motor needs to cover
      If direction is UP
            Return percentage * total number of ticks to get from bottom
            to top
      If direction is DOWN
            Return percentage * total number of ticks to get from top to
            bottom
}

Start motor {
      If direction is UP
            Set direction bit HI
            Turn motor on
      If direction is DOWN
            Set direction bit LO
```

```
            Turn motor on
      If direction is 0
            Stop the motor
      Update paper moving array
}

At limit (returns state of limit switch) {
      If paper stack limit switch is HI, it's in the middle of travel,
      return FALSE
      Else return TRUE
}

Just Hit Limit (returns true if there has been a state change in the
limit switch since the last check) {
      If the last limit hit isn't the same as the current limit state
      we're in, we know there's been a change in state
            Set the current limit state to the one we're in (zero if
            we're not at a limit)
            If we're at a limit now, return true
}
```

Interface.c – UI functions

```
Get Level (returns the level as set by the pot) {
      Read the pin the pot is connected to
      If it's between the limits set for EASY, return EASY
      If it's between the limits set for MEDIUM, return MEDIUM
      Else return HARD
}

Initialize prize dispensing {
      Start timer for flywheel warmup
      Turn on flywheel
}

Check for prize dispensing (returns true if dispensing is complete) {
      If flywheel isn't ready yet
            If flywheel timer has expired
                  Set dispenser timer
                  Set flywheel to ready
                  Turn on dispenser motor
            Return false
      If the prize dispensed state is low
            Check for expired prize dispenser timer
                  If timer's up
                  Prize dispensed state goes high
                  Turn off both flywheel and dispenser motor
            Return false
      If the timers have both expired
            Set both flags low
            Return true
}

Reset button tripped (returns true if start button has been held down
for set length of time to reset game) {
      If the button is down and it wasn't last time we checked
            Set timer for length of time we need for a reset
            Set button down flag high
            Return false
      If the bit is no longer high, but our flag hasn't been updated
            update the flag, Return false
      If the button isn't down
            Set flag low, Return false
      If the button is down and we've been holding it there
            Check if the timer has expired
            If it has, return true
}
```

LED.c - Module for controlling all LEDs

```
Control LED (this turns a given LED on, off, or to blinking) {
      If state is ON
            Set blinking flag to 0
            Turn that LED on
      If state is OFF
            Set blinking flag to 0
            Turn LED off
      Else, we must be blinking
            Set blinking flag high
            Blink that LED
}

Blink LED (uses an array of states to control blinking) {
      Check if blink timer needs initializing
      If it does, initialize it
      If the timer has expired, we need to change the state of the LEDs
            Cycle through each LED
                  If its state is set to blink
                        If it was on before, turn it off
                        Otherwise, turn it on
            Reset the timer
}

Turn off LED (takes a light ID, sets that bit LO)

Turn on LED (takes a light ID, sets that bit HI)

Turn all off {
      Cycles through each light ID
            Turns off that LED
}
```

Servo.c - Module to control servo

```
Set Servo Angle (sets the angle of the servo to the specified angle) {
      Convert the angle to a duty cycle quantity
      If the angle is set to the ergo angle, set the ergo flag high
      Otherwise, set that flag low
      Set the duty cycle of the servo to the calculated value
}
```

Convert angle to duty (returns the duty cycle scaled between the min and max values according to the specified angle)

Management away (returns the servo to the neutral angle)

Stapler.c - Module for stapler I/O

```
Check staple press (given a player number, returns if they've stapled or
not)
      For player 1:
            If the stapler switch is down and this is a new state
                  Update state
                  If we're above level EASY, decrement staples in
                  stapler
                  Return 1
            If the stapler is not down and the current state is high
                  The stapler has been released! Update state variable
      For player 2:
            If the stapler switch is down and this is a new state
                  Update state
                  If we're above level EASY, decrement staples in
                  stapler
                  Return 1
            If the stapler is not down and the current state is high
                  The stapler has been released! Update state variable
}

Has reloaded (returns true if given player has reloaded stapler) {
      For player 1:
            If the player needs to reload
                  Check for stapler opening, set state variable
                  Check for stapler closing, set state variable
                  If both conditions satisfied
                        Refill stapler
                        Reset all flags
                        Return 1
      For player 2:
            If the player needs to reload
                  Check for stapler opening, set state variable
                  Check for stapler closing, set state variable
                  If both conditions satisfied
                        Refill stapler
                        Reset all flags
                        Return 1
}

Refill Staplers {
      Set player 1 staples left to max
      Set player 2 staples left to max
      Reset reload flags
}

Check Stapler (returns true if the stapler has been opened or closed,
helper for reload function) {
      If player 1:
            If OPEN:
                  If the stapler is open and this is a new state
                        Set open flag to high
                        Return 1
            If CLOSED
                  If the stapler is closed and this is a new state
                        Set closed flag to high
                        Return 1
      If player 2:
            If OPEN:
                  If the stapler is open and this is a new state
                        Set open flag to high
                        Return 1
            If CLOSED
```

```
                  If the stapler is closed and this is a new state
                        Set closed flag to high
                        Return 1
}

Used a staple (handles player decrementing staples count) {
      If player 1:
            If the number of staples left is less than 1,
                  Set reload needed flag high
            Else, decrement staple count
      If player 2:
            If the number of staples left is less than 1,
                  Set reload needed flag high
            Else, decrement staple count
```

Helpers.c - low level functions for use in any module

```
Wait (takes a given amount of ms and delays that amount) {
      Set delay timer
      Do nothing until it expires
}
```

APPENDIX A

CODE

Helpers.h

```
#ifndef HELPERS
#define HELPERS

//DEFINITIONS
//Boolean definitions
#define TRUE 1
#define FALSE 0
#define SUCCESS 1
#define FAILURE 0
#define OPEN 1
#define CLOSED 0

//Levels of difficulty
#define EASY 1
#define MEDIUM 2
#define HARD 3

//Timer says hi
#define TIMER_TIME_BASE 1 //number of milliseconds equal to one tick

//FUNCTION PROTOTYPES
void Wait(int ticks);
#endif
```

Helpers.c

```
//wait for a given number of milliseconds

//INCLUDES
#include "headers.h"

void Wait(int ticks)
{
    //uses timer 0, which is one of 8 possible timers
    TMRS12_InitTimer(0,ticks);
    while(TMRS12_IsTimerExpired(0) != TMRS12_EXPIRED);
}
```

Interface.h

```
#ifndef INTERFACE
#define INTERFACE

//FUNCTION PROTOTYPES
char GetLevel(void);
void InitDispensePrize(void);
char CheckDispensePrize(void);
char LevelSubmitted(void);
char ResetButton(void);

#endif
```

Interface.c

```
//CONSTANT DEFINITIONS
#define LEVEL_TRANSITION_EM 220 //voltage in mV at which level transitions from easy to medium
#define LEVEL_TRANSITION_MH 600    //voltage in mV at which level transitions from medium to hard
#define FLYWHEEL_WARMUP_TIME 2000 //amount of time required to spin up the flywheel
#define DISPENSE_TIME 30      //time in ms that prize dispensing motor is on
#define RELAX_TIME 3000      //time to relax before the game is officially over
#define RESET_BUTTON_TIMEOUT 3000  //time in ms you have to hold down reset button for a reset

//MODULE VARIABLE DEFINITIONS
static char levelSubmitted = 0;    //state variable set to 1 if start button pressed
static char resetButtonDown = 0;   //state variable set to 1 if button is down
static char flywheelReady = 0; //state variable set to 1 when the flywheel is warmed up and ready to go
static char prizeDispensed = 0; //state variable set to 1 when the prize has been dispensed

//INCLUDES
#include "headers.h"

char GetLevel(void) {
    //AD0 - Analog level select, ranges between 0 and 1023
    short potVoltage = ADS12_ReadADPin(0);
    //printf("potV: %d\r\n",potVoltage);

    //return a level based on the pot voltage and transition points
    if(potVoltage < LEVEL_TRANSITION_EM)
        return EASY;
    else if(potVoltage < LEVEL_TRANSITION_MH)
        return MEDIUM;
```

```
    else
        return HARD;
}

void LevelTest(void) {
    short potVoltage;
    char Level=GetLevel();
    while(TRUE){          //while()
        potVoltage = ADS12_ReadADPin(0);
        printf("potV: %d\r\n",potVoltage);
        Wait(100);
    }
}

//Call this once to initialize prize dispensing
void InitDispensePrize(void) {
    TMRS12_InitTimer(3,FLYWHEEL_WARMUP_TIME); //start timer
    PTAD = (PTAD | BIT7HI); //turn on flywheel motor
}

/* PUBLIC FUNCTION: char CheckDispensePrize(void)
  description: returns true if prize dispensing is complete and the postgame is over
  pre: -
  post: -
  returns true or false
*/
char CheckDispensePrize(void) {
    if(flywheelReady == 0){    //haven't yet warmed up, so do it
        if(TMRS12_IsTimerExpired(3) == TMRS12_EXPIRED){ //check to see if our flywheel is ready to rock
            TMRS12_InitTimer(3,DISPENSE_TIME); //now this timer will control the length of time dispensing
will take place
            flywheelReady = 1;
            PTT = (PTT | BIT5HI); //turn on dispensing motor
        }
        return FALSE;
    }
    else if(prizeDispensed == 0) {  //ting-a-ling! we're ready to shoot business cards.
        //check if we should be done dispensing
        if(TMRS12_IsTimerExpired(3) == TMRS12_EXPIRED){
            TMRS12_InitTimer(3,RELAX_TIME); //now this timer will control the length of time dispensing
```

```
will take place
            prizeDispensed = 1;
            PTT = (PTT & BIT5LO); //after time's up, turn off both motors
            PTAD = (PTAD & BIT7LO); //turn off flywheel
        }
        return FALSE;
    }
    else { //all done dispensing the prize. Let's relax for a bit, then return true
        if(TMRS12_IsTimerExpired(3) == TMRS12_EXPIRED) {
            flywheelReady = 0;
            prizeDispensed = 0;
            return TRUE;
        }
        return FALSE;
    }
    return FALSE;
}

char LevelSubmitted(void){
     // get current state of start button
     levelSubmitted = BIT2HI & PTAD;

     // returns 1 if start button pressed
     return levelSubmitted;
}

char ResetButton(void){
     //if button is down and it's a new thang
     if ((PTAD & BIT2HI) && !resetButtonDown) {
        //set the timer and set state of button to down
        TMRS12_InitTimer(5, RESET_BUTTON_TIMEOUT);
        resetButtonDown = 1;
        return 0;
     }

     //if the bit isn't high but our state doesn't reflect that, update the state
     if (!(PTAD & BIT2HI) && resetButtonDown) {
        resetButtonDown = 0;
        return 0;
     }
```

```
      //if button isn't down
      if (!(PTAD & BIT2HI)) {
         resetButtonDown = 0;
         return 0;
      }

      //if button is down and we're holding it there
      if ((PTAD & BIT2HI) && resetButtonDown){
         //check if the timer has expired
         //if timer 5 has expired, we set the reset flag
         if (TMRS12_IsTimerExpired(5) == TMRS12_EXPIRED) {
             printf("YOU JUST RESET THE GAME!!!\r\n");
             return 1;
         } else return 0;
      }
}
```

LED.h

```
/*
LED.h

Description: This is the header file the module which provides
all of the functions necessary to control the LED's
used in the game
*/

#ifndef LED
#define LED

#define OFF 0
#define ON 1
#define BLINK 2

#define RELOAD_LIGHT_1 0
#define RELOAD_LIGHT_2 1
#define STAPLER_LIGHT_1 2
#define STAPLER_LIGHT_2 3
#define PAYCHECK_LIGHT 4
#define START_LIGHT 5
#define ERGO_INSTRUCT_LIGHT 6

/*
Function Prototypes
*/

//state is OFF, ON, or BLINK;
void ControlLED(char state, int lightID);
void LEDTest(void);
void TurnAllOff(void);

//used as accessory function to ControlLED
static void TurnOffLED(int lightID);
static void TurnOnLED(int lightID);
void BlinkLED(void);

#endif
```

LED.c

```
/*
LED.c
```

```
Description: This is the code file the module which provides
all of the functions necessary to control the LED's
used in the game
*/
#include "headers.h"
#include "led.h"

/*
Constants
*/
#define BLINK_RATE 300
#define NUM_LEDS 6       //the total number of LEDs we are controlling
#define TIMER_NUMBER 4

/*
Module Variables
*/
static char LED_State [NUM_LEDS + 1];
static char IsBlinking [NUM_LEDS + 1];

void LEDTest()
{
     int i;
     int time;

     // Cycle through all LEDs and turn on then off - then blink them for awhile
     for(i=0; i<NUM_LEDS; i++)
     {
          time = TMRS12_GetTime();
          ControlLED(ON, i);
          while((TMRS12_GetTime() - time) < BLINK_RATE);
          ControlLED(OFF, i);
          ControlLED(BLINK, i);
     }

     time = TMRS12_GetTime();
     while((TMRS12_GetTime()-time) < 5000) BlinkLED();

     for(i=0; i<NUM_LEDS; i++) TurnOffLED(i);
```

```
}

void ControlLED(char state, int lightID)
{
     if(state == ON)
     {
        IsBlinking[lightID] = 0;
        TurnOnLED(lightID);
     }
     else if (state == OFF)
     {
        IsBlinking[lightID] = 0;
        TurnOffLED(lightID);
     }
     else
     {
        IsBlinking[lightID] = 1;
        BlinkLED();
     }
}

void BlinkLED(void)
{

     int i;

     // Check to see if blink timer needs first initialization
     if(TMRS12_IsTimerActive(TIMER_NUMBER) == TMRS12_NOT_ACTIVE && TMRS12_IsTimerExpired(TIMER_NUMBER) !=
TMRS12_EXPIRED)
     {
          TMRS12_InitTimer(TIMER_NUMBER, BLINK_RATE);
          //printf("\r\ninitialized blink timer\r\n\r\n");
     }

     // If the blink timer has expired, we need to change the state of the LEDs (otherwise do nothing)
     if(TMRS12_IsTimerExpired(TIMER_NUMBER) == TMRS12_EXPIRED)
     {
          //printf("blink timer expiration detected\r\n");
          for (i=0;i<NUM_LEDS;i++)                                        //cycle through each LED
          {
```

```
                //check if each LED is supposed to be blinking
                if(IsBlinking[i])
                {
                  //if it was on, turn it off
                  if(LED_State[i] == ON) TurnOffLED(i);
                  //if it was off, turn it on!
                  else TurnOnLED(i);
                }
            }
            // Reset the timer
            TMRS12_InitTimer(TIMER_NUMBER, BLINK_RATE);
            //printf("blink timer just reset\r\n");
      }
}

static void TurnOffLED(int lightID)
{
      switch(lightID)
      {
      case RELOAD_LIGHT_1:
            PTT = PTT & BIT6LO;
            LED_State[RELOAD_LIGHT_1] = 0;
            break;
      case RELOAD_LIGHT_2:
            PTT = PTT & BIT7LO;
            LED_State[RELOAD_LIGHT_2] = 0;
            break;
      case STAPLER_LIGHT_1:
            PTAD = PTAD & BIT3LO;
            LED_State[STAPLER_LIGHT_1] = 0;
            break;
      case STAPLER_LIGHT_2:
            PTAD = PTAD & BIT4LO;
            LED_State[STAPLER_LIGHT_2] = 0;
            break;
      case PAYCHECK_LIGHT:
            PTAD = PTAD & BIT5LO;
            LED_State[PAYCHECK_LIGHT] = 0;
            break;
      case START_LIGHT:
```

```
            PTAD = PTAD & BIT6LO;
            LED_State[START_LIGHT] = 0;
            break;
      default:
            break;
      }
}

static void TurnOnLED(int lightID)
{
      switch(lightID)
      {
      case RELOAD_LIGHT_1:
            PTT = PTT | BIT6HI;
            LED_State[RELOAD_LIGHT_1] = 1;
            break;
      case RELOAD_LIGHT_2:
            PTT = PTT | BIT7HI;
            LED_State[RELOAD_LIGHT_2] = 1;
            break;
      case STAPLER_LIGHT_1:
            PTAD = PTAD | BIT3HI;
            LED_State[STAPLER_LIGHT_1] = 1;
            break;
      case STAPLER_LIGHT_2:
            PTAD = PTAD | BIT4HI;
            LED_State[STAPLER_LIGHT_2] = 1;
            break;
      case PAYCHECK_LIGHT:
            PTAD = PTAD | BIT5HI;
            LED_State[PAYCHECK_LIGHT] = 1;
            break;
      case START_LIGHT:
            PTAD = PTAD | BIT6HI;
            LED_State[START_LIGHT] = 1;
            break;
      default:
            break;
      }
}
```

```
void TurnAllOff(void)
{
    int i;
    for (i=0;i<NUM_LEDS;i++) ControlLED(OFF,i);
}
```

Paper.h

```
#ifndef PAPER
#define PAPER

//motorID constants
#define PAPER1 0 //motorIDs, which correspond the the array indexes of paper stack state variables
#define PAPER2 1

//function prototypes
void PopupTest(char motorID);
char CalibratePopup(char motorID);
char GetPopupPos(char motorID);
void SetPopup(char motorID, char finalPos);
char CheckAllPopupsForArrival(void);
static char CheckPopupArrival(char motorID);
static int CalculateMoveDuration(int diffPos, char direction, char motorID);
static void StartMotor(char motorID, char direction, unsigned char dutyCycle);
static void StopMotor(char motorID);
static char JustHitLimit(char motorID);
static char AtLimit(char motorID);

#endif
```

Paper.c

```
///////////////
//  paper.c  //
///////////////

/*
OVRERVIEW: the paper.c module controls the paper stacks using three public functions.
1) CalibratePopup must be run before any other paper functions are used. As a precondition, the paper
stacks must not be at their limit switches. The paper stacks will end at the down position.
2) SetPopup is used to set the position of a chosen paper stack to an absolute position anywhere from 0
(bottom) to 100 (top)
3) CheckAllPopupsForArrival must be called continuously in an event-checking loop. It makes sure the paper
stacks stop when they hit their destinations or limits, and returns true if all the paper stacks are in
place
*/

//INCLUDES
#include "headers.h"  //includes all headers

//constant definitions
```

```
//direction constants
#define UP 1   //paper stack moving upwards
#define DOWN (-1) //paper stack moving downwards
#define TOP 1 //paper stack limit at the top of travel
#define BOTTOM (-1) //paper stack limit at the bottom of travel

//limits definitions and adjustment constants
#define MAX_PAPER_POSITION 100 //arbitrary max end of paper position range
#define MIN_PAPER_POSITION 0 //arbitrary min end of paper position range
#define DEF_PAPER_DUTY 60 //default duty cycle for paper movement
#define DUTY_UP_FACTOR 150 //multiplier for duty cycle when going up

//module variable definitions
//array variables are sized according to the number of paper stacks, which equals 2 for this game
static char paperMoving[2] = {0,0}; //are the paper stacks moving up, down, or 0?
static char paperLastLimit[2] = {0,0}; //1 if paper is at a limit, 0 if it isn't at a limit.

//RSVP inputs, outputs, and timers for the paper stacks
static int paperPosition[2] = {0, 0}; //destination position of paper (from 0 = max down to 100 = max up)
assume a start at the middle
static char limitPortsHI[2] = {BIT4HI, BIT5HI}; //which PTM ports are the paper stacks attached to?
static char motorDirectionPortsHI[2]= {BIT3HI, BIT4HI}; //PTM
static char motorDirectionPortsLO[2]= {BIT3LO, BIT4LO}; //PTM
static char motorEnablePorts[2]= {PWMS12_CHAN0, PWMS12_CHAN1}; //PTM
static char motorTimerNumbers[2]={1, 2}; //reserve timers one and two

//the following variables need to be set during the calibration routine:
static int upTicks[2] = {900, 900}; //IF MOVING UP, how many ticks does it take to go all the way from
lower to upper limit? Needs to be calibrated.
static int downTicks[2] = {900, 900}; //IF MOVING DOWN, how many ticks does it take to go all the way from
upper to lower limit? Needs to be calibrated.


/* PUBLIC FUNCTION: void PopupsTest(char motorID)
  description: runs a routine to test the given popup
  pre: attach popup prototype with motor and limit switch
  post: -
  returns nothing
*/
void PopupTest(char motorID){
```

```
int i;

//Tell the world what's up
if(motorID == PAPER1){
    printf("Popup test for PAPER STACK 1: \r\n");
}
else if(motorID == PAPER2){
    printf("Popup test for PAPER STACK 2: \r\n");
}

//check limit switch
printf("Checking limit switch \r\n");
for(i=0; i<100; i++){
    Wait(400);
    if(AtLimit(motorID))
        printf("At limit \r\n");
    else
        printf("NOT at limit \r\n");

    if(JustHitLimit(motorID))
        printf("Just hit limit \r\n");
}

//Calibrate the first popup
//CalibratePopup(motorID);

/*
//Check SetPopup function
SetPopup(motorID, 60);
printf("Going to abs 60 \r\n");
while(!CheckAllPopupsForArrival());
printf("Arrived at abs 60 \r\n");
SetPopup(motorID, 20);
printf("Going to abs 20 \r\n");
while(!CheckAllPopupsForArrival());
printf("Arrived at abs 20 \r\n");
SetPopup(motorID, 100);
printf("Going to abs 100 \r\n");
while(!CheckAllPopupsForArrival());
printf("Arrived at abs 100 \r\n");
```

```
    SetPopup(motorID, 0);
    printf("Going to abs 0 \r\n");
    while(!CheckAllPopupsForArrival());
    printf("Arrived at abs 0 \r\n");
    */
}

/* PUBLIC FUNCTION: char CalibratePopup(char motorID)
  description: automatically calibrates paper stack to know how long to pulse
  pre: stacks are in the middle of travel, away from limits
  post: stacks in the lower position
  return char: 1 if calibration was successful, 0 if it failed
*/
char CalibratePopup(char motorID){
    int startTime;

    printf("\r\nBeginning popup calibration: \r\n");

    //return an error and do not calibrate if you start at a limit, since you don't know which limit you're
at
    if(AtLimit(motorID)){
        printf("ERROR: Calibration must start with paper stack between limits \r\n");
        return 0;
    }
    //go down until the lower limit is hit
    SetPopup(motorID, MIN_PAPER_POSITION);
    printf("1) Travelling to lower limit \r\n");
    //MAY NEED TO DEBOUNCE HERE
    while(!CheckPopupArrival(motorID)); //kill time until the stack arrives where it should be
    printf("   Reached the lower limit \r\n");
    Wait(1000); //pause to let the motor chill out for a wee bit

    //start a timer
    startTime = TMRS12_GetTime();

    //start going up until the upper limit is hit
    SetPopup(motorID, MAX_PAPER_POSITION);
    printf("2) Travelling to upper limit \r\n");
    while(!CheckPopupArrival(motorID));
    printf("   Reached the upper limit \r\n");
```

```
    //stop the timer and calculate the elapsed time
    upTicks[motorID] = TMRS12_GetTime() - startTime;
    printf("upTicks = %d \r\n", upTicks[motorID]);
    Wait(1000); //pause to let the motor chill out for a wee bit

    //start a timer
    startTime = TMRS12_GetTime();

    //now go down until the lower limit is hit
    SetPopup(motorID, MIN_PAPER_POSITION);
    printf("3) Travelling to lower limit \r\n");
    while(!CheckPopupArrival(motorID));
    printf("   Reached the lower limit \r\n");

    //stop the timer and calculate the elapsed time
    downTicks[motorID] = TMRS12_GetTime() - startTime;
    printf("downTicks = %d \r\n", downTicks[motorID]);
    Wait(1000); //pause to let the motor chill out for a wee bit

    printf("Calibration complete!\r\n");
    return 1;
}

//PUBLIC FUNCTION
//Given a motor, returns the current position of the motor
char GetPopupPos(char motorID){
    return paperPosition[motorID];
}

/* PUBLIC FUNCTION: void SetPopup(char motorID, char finalPos)
  description: given a final position, goes to it. It you set a max position as a final destination, it
goes until the limit is hit. Otherwise it sets the stop time for getting to an intermediate destination.
  pre: calibration must be performed before SetPopup can be called
  post: have to check the motor's arrival continuously until the motor has arrived, or suffer the collision
consequences
  returns nothing
*/
void SetPopup(char motorID, char finalPos){
    char diffPos;
```

```
    char direction = 0;
    int numTicks;

    printf("Setting motorID=%d popup to finalPos=%d \r\n", motorID, finalPos);

    if(paperMoving[motorID] && (finalPos > MIN_PAPER_POSITION) && (finalPos < MAX_PAPER_POSITION)){ //if
it's already moving, do nothing
        //printf("WARNING: Trying to move a motor that's already in motion \r\n");
        return;
    }
    //If you're going to min or max, just plow forward until you hit a limit
    if(finalPos <= MIN_PAPER_POSITION){
        if(paperPosition[motorID] == MIN_PAPER_POSITION) //we are already at min
          return;
        TMRS12_ClearTimerExpired(motorTimerNumbers[motorID]); //NOT NEEDED?
        StartMotor(motorID, DOWN, DEF_PAPER_DUTY);  //go motor! No timer needed becuase we want it to go
all the way to the limit
        paperPosition[motorID] = MIN_PAPER_POSITION;        //will end up at the destination
        //******
        if(AtLimit(motorID)){ //if we're trying to go end to end, allow a grace period
            Wait(200);
        }
    }
    else if(finalPos >= MAX_PAPER_POSITION){
        if(paperPosition[motorID] == MAX_PAPER_POSITION) //we are already at max
          return;
        TMRS12_ClearTimerExpired(motorTimerNumbers[motorID]);
        StartMotor(motorID, UP, DEF_PAPER_DUTY);
        paperPosition[motorID] = MAX_PAPER_POSITION;

        if(AtLimit(motorID)){ //if we're trying to go end to end, allow a grace period
            Wait(200);
        }
    }
    else{ //you are actually in a happy place in between the limits
        if(finalPos > paperPosition[motorID]){ //going up
            direction = UP;
            diffPos = finalPos - paperPosition[motorID]; //should be a positive value
            //printf("going up a relative %d ticks \r\n", diffPos);
        }
```

```
        else if(finalPos < paperPosition[motorID]){ //going down
            direction = DOWN;
            diffPos = paperPosition[motorID] - finalPos;  //should be a positive value
            //printf("going down a relative %d ticks \r\n", diffPos);
        }
        //update motor position and states
        numTicks = CalculateMoveDuration(diffPos, direction, motorID);
        TMRS12_InitTimer(motorTimerNumbers[motorID], numTicks);
        StartMotor(motorID, direction, DEF_PAPER_DUTY);
        paperPosition[motorID] = finalPos;
    }
}

/* PUBLIC FUNCTION: char CheckAllPopupsForArrival(void)
  description: a checking and handling function that stops the paper stacks if they hit limits or run out
of time. Use in an event-checking loop..
  pre: none
  post: motors stopped if they need to be
  return char: true if all systems are stopped,  false if any paper stack is still in motion
*/
char CheckAllPopupsForArrival(void){
    char CPA1;
    char CPA2;
    CPA1 = CheckPopupArrival(PAPER1);
    CPA2 = CheckPopupArrival(PAPER2);
    //if nothing's moving, our job's done here
    if(CPA1 && CPA2){
        return TRUE; //all systems are stopped
    }
    return FALSE; //at least one of the stacks is still moving
}

/* PRIVATE FUNCTION: static char CheckPopupArrival(char motorID)
  description: a checking and handling function that stops the given paper stack if it hits its limits or
run out of time.
  pre: none
  post: motor stopped if it needs to be
  return char: true if the motor is stopped,  false if it is still in motion
*/
static char CheckPopupArrival(char motorID){
```

```
    //if stack is moving,  stop if needed
    if(paperMoving[motorID] != 0){ //if paper is moving
        //printf("PAPER IS MOVING \r\n");
        if(JustHitLimit(motorID)){
            //make sure if we hit a limit, we update our position to know where we are
            if(paperMoving[motorID] == DOWN) {
                printf("paperPosition[0]=%d \r\n", paperPosition[0]);
                printf("paperPosition[1]=%d \r\n", paperPosition[1]);
                printf("paperMoving[0]=%d \r\n", paperMoving[0]);
                printf("paperMoving[1]=%d \r\n", paperMoving[1]);
                printf("paperLastLimit[0]=%d \r\n", paperLastLimit[0]);
                printf("paperLastLimit[1]=%d \r\n", paperLastLimit[1]);

                paperPosition[motorID] = MIN_PAPER_POSITION;
                printf("Reinterpreted position of motor %d to MIN \r\n", motorID);
            }
            if(paperMoving[motorID] == UP){
                paperPosition[motorID] = MAX_PAPER_POSITION;
                printf("Reinterpreted position of motor %d to MAX \r\n", motorID);
            }
            TMRS12_ClearTimerExpired(motorTimerNumbers[motorID]);
            StopMotor(motorID);
        }
        if(TMRS12_IsTimerExpired(motorTimerNumbers[motorID]) == TMRS12_EXPIRED){
            TMRS12_ClearTimerExpired(motorTimerNumbers[motorID]);
            StopMotor(motorID);
        }
        return FALSE; //one of the stacks is still moving
    }
    return TRUE; //stacks aren't moving
}

/* PRIVATE FUNCTION: static int CalculateMoveDuration(int diffPos, char direction, char motorID)
  description: given a difference in position, find how long it should move
  pre: calibration completed
  post: none
  return int: the number of ticks the paper stack should move for
*/
static int CalculateMoveDuration(int diffPos, char direction, char motorID){
    int posPercent = (100 * diffPos) / (MAX_PAPER_POSITION - MIN_PAPER_POSITION); //ranges from 0 (down) to
```

```
100 (up)
    int ticksMove;
    //printf("posPercent = %d \r\n", posPercent);

    if (direction == UP){
        ticksMove = posPercent * (upTicks[motorID] / 100);
        printf("MoveDurationUp = %d \r\n", ticksMove);
        return (ticksMove);
    }
    else if (direction == DOWN){
        ticksMove = posPercent * (downTicks[motorID] / 100);
        printf("MoveDurationDown = %d \r\n", ticksMove);
        return (ticksMove);
  }
  else{
        printf("WARNING: Trying to calculate a move duration without a direction!");
        return 0;
    }
}

/* PRIVATE FUNCTION: static void StartMotor(char motorID, char direction, unsigned char dutyCycle)
  description: starts the selected motor going in a direction with a given duty cycle, taking into account
the weight of the popup
  pre: motor attached, voltage and duty high enough that the motor doesn't stall. See L239B data sheet for
motor control details.
  post: motor moving with given speeed and direction, paperMoving properly updated
  returns nothing
*/
static void StartMotor(char motorID, char direction, unsigned char dutyCycle){
    if(direction == UP){
        PTT = PTT | motorDirectionPortsHI[motorID]; //set direction bit high
        PWMS12_SetDuty((dutyCycle*DUTY_UP_FACTOR)/100, motorEnablePorts[motorID]); //use PWM output to set
the motor in motion
    }
    else if(direction == DOWN){
        PTT = PTT & motorDirectionPortsLO[motorID]; //set direction bit low
        PWMS12_SetDuty(dutyCycle, motorEnablePorts[motorID]);
    }
    else{ //if the direction is zero, stop the motor
        PWMS12_SetDuty(0, motorEnablePorts[motorID]);
```

```
    }
    //set the paperMoving state
    paperMoving[motorID] = direction;
}

/* PRIVATE FUNCTION: static void StopMotor(char motorID)
  description: stops the selected motor
  pre: preconditions for StartMotor must be met
  post: stops the selected motor
  returns nothing
*/
static void StopMotor(char motorID)
{
    printf("STOPPING MOTOR %d \r\n", motorID);
    StartMotor(motorID, 0, 0);
}

/* PRIVATE FUNCTION: static char JustHitLimit(char motorID)
  description: a wrapper of AtLimit that identifies when a limit is immediately hit
  pre: limit switch attached, a valid motorID must be given
  post: none
  returns char: returns TRUE if the motor just hit a limit, FALSE if it has been at a limit for awhile or
just left a limit*/
static char JustHitLimit(char motorID){
    char curLimitState = AtLimit(motorID);
    if(paperLastLimit[motorID] != curLimitState){
        paperLastLimit[motorID] = curLimitState;
        if(curLimitState == TRUE){ //return true if it just hit a limit, but not if it just came off one
            printf("JUST HIT LIMIT for motorID %d \r\n", motorID);
            return TRUE;
        }
    }
    return FALSE;
}
/* PRIVATE FUNCTION: AtLimit(char motorID)
  description: limit-checking function
  pre: limit switch attached, a valid motorID must be given
  post: none
  returns char: 1 if limit switch is open, 0 if limit switch is closed*/
static char AtLimit(char motorID){
```

```
    if(PTM & limitPortsHI[motorID]){ //if paper stack limit switch is high, then it is depressed and in the
middle of travel (not at a limit)
        Wait(10);
        return FALSE;
    }
    Wait(10);
    return TRUE;
}
```

Play.h

```
#ifndef PLAY
#define PLAY

//FUNCTION PROTOTYPES
static void MainEventChecker(void);
static void RunChecks(void);
static void InitMAIN(void);
static void InitRESET(void);
static void InitWAITCOIN(void);
static void InitWAITSTART(void);
static void InitPREGAME(void);
static void InitGAME(void);
static void InitPOSTGAME(void);
static char IsWinner(void);
static char CheckCoin(void);

#endif
```

Play.c

```
//Uncomment the following line to run the full set of tests
//#define TEST

/*
THE STAPLER GAME DOCUMENTATION

OUTPUTS (8)
    T0 - Paper stack 1 motor control 1 (C) (PWM group 0)
    T1 - Paper stack 2 motor control 1 (C) (PWM group 0)
    T2 - Boss/ergo servo motor signal (PWM group 1)
    T3 - Paper stack 1 motor control 2 (D)
    T4 - Paper stack 2 motor control 2 (D)
    T5 - Prize motor signal
    T6 - Reload light 1
    T7 - Reload light 2
    AD3 - Stapler light 1
    AD4 - Stapler light 2
    AD5 - Paycheck light
    AD6 - Level select and start light
    AD7 - Prize flywheel motor

INPUTS (8)
```

```
    AD0 - Analog level select
    AD1 - Coin sensor
    AD2 - Start button
    M0 - Stapler press 1
    M1 - Stapler press 2
    M2 - Stapler reload 1
    M3 - Stapler reload 2
    M4 - Paper stack 1 limit switches
    M5 - Paper stack 2 limit switches

TIMERS (8)
    0 - Wait helper function & staple test
    1 - Paper stack 1
    2 - Paper stack 2
    3 - Prize dispenser
    4 - LED blinking
    5 - Reset button
    6 - Ergo
    7 - UNUSED!
*/

/*
PLAY MODULE
Description:    This is the highest-level module.  It calls all initializations necessary to play the game
and then begins an infinite loop where it is constantly listens for events and then responds to the events
in an appropriate way.
*/

//Management states
#define AWAY 0
#define ERGO 1
#define BOSS 2

//GameStage definitions
#define RESET 1 //Transition to start conditions
#define WAITCOIN 2 //The period when we are waiting for a player to insert a coin
#define WAITSTART 3 //The period when we are waiting for a player to select a level and hit start
#define PREGAME 4 //From coin insertion until the start of play begins
#define GAME 5 //The main game until a winner is declared
#define POSTGAME 6 //Winning sequence and prize delivery
```

```
//Game-winning scores!
#define EASY_WIN_SCORE 40   //number of staples needed to win the easy level
#define MEDIUM_WIN_SCORE 60 //number of staples needed to win the medium level
#define HARD_WIN_SCORE 60   //number of staples needed to win the hard level

//Game timeout definition
#define TIMEOUT 480000

#define PREGAME_LENGTH 2000 //how long the pregame sequence lasts (in ms)
#define POSTGAME_LENGTH 6000 //how long the postgame sequence lasts (in ms)

#define ERGO_TIME 5000 //how long you have till the ergo shows up
#define ERGO_GRACE_PERIOD 500 //number of milliseconds grace period before getting caught by ergo
#define ERGO_PUNISHMENT 10 //number of papers HR adds to the stack to punish you
#define ERGO_TIME_UP 3000 //how much time you have to spend with her watching you!
#define LEVEL_SPEED_MULTIPLIER_E 60
#define LEVEL_SPEED_MULTIPLIER_M 70

//MODULE VARIABLE DEFINITION
static char GameStage = RESET; //a variable that keeps track of what stage of the game we are in and is
used by the main event checker.
static char Level = 0; //Level keeps track of the difficulty level that the user chooses

static int P1score = 0; //cumulative player 1 score
static int P2score = 0; //cumulative player 2 score
static char PaperStack1Pos = 0; //position of paper stack 1 from 0 to 100
static char PaperStack2Pos = 0; //position of paper stack 2 from 0 to 100
static char Management = AWAY; //who's looking over the cubicle walls?
static char ErgoAlreadyCame = 0; //goes high if the ergonomist has already wreaked her havoc
static char P1gotcha = 0; //goes high if the ergonomist catches you. Prevents double jeopardy
static char P2gotcha = 0;
static char coinInserted;

static int StageStartTime = 0; //the clock tick time when the game started
static int ErgoStartTime = 0; //time when the ergonomist pops up (if lvl 3)

//INCLUDES
#include "headers.h"
```

```
//The REAL main function, which is disabled if we are in testing mode
#ifndef TEST
void main(void)
{
     //Perform main initialization sequence
     InitMAIN();
     printf("main initialized\r\n");

     //Initialize reset once
     InitRESET();
     printf("just reset\r\n");

     //Run main event checker in an endless loop
     while(TRUE)
     {
          MainEventChecker();
     }
     return;
}
#endif


//MainEventChecker
//This is our main event loop, which will always be running in a loop.
//Functions called within MainEventChecker must be non-blocking
static void MainEventChecker(void)
{
     //check for interrupts and refresh continuous state variables
     RunChecks();

     switch(GameStage)
     {
     case RESET:
          //Once mechanical elements are in place and no longer moving, you're done resetting. Wait for
coin!
          if(CheckAllPopupsForArrival())
          {
               //Initialize waitcoin once
               printf("in reset phase\r\n");
               TurnAllOff();
```

```
          InitWAITCOIN();
          GameStage=WAITCOIN;
     }
     break;

case WAITCOIN:
     //When a coin is sensed, go to waitstart
     if(CheckCoin())
     {
          printf("just sensed coin\r\n");
          //Initialize waitstart once
          InitWAITSTART();
          GameStage=WAITSTART;
     }
     break;

case WAITSTART:
     //check the level
     Level = GetLevel();

     //When the start button is pressed, go to the pregame
     if(LevelSubmitted())
     {
          printf("level has been submitted: %d\r\n",Level);
          //Initialize pregame once
          InitPREGAME();
          GameStage=PREGAME;
     }
     break;

case PREGAME:
       if(CheckAllPopupsForArrival()){
           //Initialize game once
           InitGAME();
           GameStage=GAME;
       }
     break;

case GAME:
     //Check for winner. If there is one, end the game.
```

```
          if(IsWinner())
          {
               //Initialize postgame once
               printf("we have a winner!!!\r\n");
               InitPOSTGAME();
               GameStage=POSTGAME;
               break;
          }

          switch(Level)
          {
          case EASY:
               //Check if player 1 has stapled
               if(CheckStaplePress(1,Level))
               {
                    //Increment score
                    P1score++;
                    //Update position of paper stack
                    PaperStack1Pos = 100 - (100 * P1score) / (100 * EASY_WIN_SCORE /
LEVEL_SPEED_MULTIPLIER_E);
                    if(PaperStack1Pos < GetPopupPos(PAPER1)) //only go down!
                        SetPopup(PAPER1,PaperStack1Pos);
               }
               //Check if player 2 has stapled
               if(CheckStaplePress(2,Level))
               {
                    //Increment score
                    P2score++;
                    //Update position of paper stack
                    PaperStack2Pos = 100 - (100 * P2score) / (100 * EASY_WIN_SCORE /
LEVEL_SPEED_MULTIPLIER_E);
                    if(PaperStack2Pos < GetPopupPos(PAPER2)) //only go down!
                        SetPopup(PAPER2,PaperStack2Pos);
               }
               break;

          case MEDIUM:
               //If player 1 has plenty of staples
               if(IsAmmoLeft(1))
               {
```

```
                    //Check if player 1 has stapled
                    if(CheckStaplePress(1,Level))
                    {
                         //Increment score
                         P1score++;
                         //Update position of paper stack
                         PaperStack1Pos = 100 - (100 * P1score) / (100 * EASY_WIN_SCORE /
LEVEL_SPEED_MULTIPLIER_M);
                         if(PaperStack1Pos < GetPopupPos(PAPER1)) //only go down!
                            SetPopup(PAPER1,PaperStack1Pos);
                    }
               }
               //If they are out of staples, they need to reload
               else
               {
                    //Illuminate the reload light only
                    ControlLED(OFF,STAPLER_LIGHT_1);
                    ControlLED(BLINK,RELOAD_LIGHT_1);

                    //Check if player reloads
                    if(HasReloaded(1))
                    {
                         //Illuminate the stapler lights only
                         ControlLED(OFF,RELOAD_LIGHT_1);
                         ControlLED(ON,STAPLER_LIGHT_1);
                    }
               }

               //If player 2 has plenty of staples
               if(IsAmmoLeft(2))
               {
                    //Check if player 1 has stapled
                    if(CheckStaplePress(2,Level))
                    {
                         //Increment score
                         P2score++;
                         //Update position of paper stack
                         PaperStack2Pos = 100 - (100 * P2score) / (100 * EASY_WIN_SCORE /
LEVEL_SPEED_MULTIPLIER_M);
                         if(PaperStack2Pos < GetPopupPos(PAPER2)) //only go down!
```

```
                    SetPopup(PAPER2,PaperStack2Pos);
               }
          }
          //If they are out of staples, they need to reload
          else
          {
               //Illuminate the reload light only
               ControlLED(OFF,STAPLER_LIGHT_2);
               ControlLED(BLINK,RELOAD_LIGHT_2);

               //Check if player reloads
               if(HasReloaded(2))
               {
                    //Illuminate the stapler lights only
                    ControlLED(OFF,RELOAD_LIGHT_2);
                    ControlLED(ON,STAPLER_LIGHT_2);
               }
          }

          break;

     case HARD:

     //////////////////
     //first scenario//
     //////////////////

          //If it's past time for the ergonomist and she hasn't already come
          if ((TMRS12_IsTimerExpired(6) == TMRS12_EXPIRED) && !ErgoAlreadyCame)
          {
               ErgoAlreadyCame = 1;
               printf("ergo going up!\r\n");
               ErgoStartTime = TMRS12_GetTime();

               //Ergonomist attacks!
               SetServoAngle(ERGO_ANGLE);

               //Illuminate the ergonomist instruction
               ControlLED(ON,ERGO_INSTRUCT_LIGHT);
```

```
          //Set gotcha flags to zero
          P1gotcha = 0;
          P2gotcha = 0;
     }

////////////////////
//second scenario//
////////////////////

     //If ergo has already wreaked her havoc, we treat it like it's MEDIUM
     //Or if the ergo hasn't shown up yet at all

     if (!ErgoIsUp())
     {
          ////////////////////////////////////////////////
          //The code for this case is identical to MEDIUM!//
          ////////////////////////////////////////////////

          //If player 1 has plenty of staples
          if(IsAmmoLeft(1))
          {
               //Check if player 1 has stapled
               if(CheckStaplePress(1,Level))
               {
                    //Increment score
                    P1score++;
                    //Update position of paper stack
                    PaperStack1Pos = 100 - (100 * P1score) / HARD_WIN_SCORE;
                    if(PaperStack1Pos < GetPopupPos(PAPER1)) //only go down!
                      SetPopup(PAPER1,PaperStack1Pos);
               }
          }
          //If they are out of staples, they need to reload
          else
          {
               //Illuminate the reload light only
               ControlLED(OFF,STAPLER_LIGHT_1);
               ControlLED(BLINK,RELOAD_LIGHT_1);

               //Check if player reloads
```

```
                if(HasReloaded(1))
                {
                    //Illuminate the stapler lights only
                    ControlLED(OFF,RELOAD_LIGHT_1);
                    ControlLED(ON,STAPLER_LIGHT_1);
                }
            }

            //If player 2 has plenty of staples
            if(IsAmmoLeft(2))
            {
                //Check if player 1 has stapled
                if(CheckStaplePress(2,Level))
                {
                    //Increment score
                    P2score++;
                    //Update position of paper stack
                    PaperStack2Pos = 100 - (100 * P2score) / HARD_WIN_SCORE;
                    if(PaperStack2Pos < GetPopupPos(PAPER2)) //only go down!
                      SetPopup(PAPER2,PaperStack2Pos);
                }
            }
            //If they are out of staples, they need to reload
            else
            {
                //Illuminate the reload light only
                ControlLED(OFF,STAPLER_LIGHT_2);
                ControlLED(BLINK,RELOAD_LIGHT_2);

                //Check if player reloads
                if(HasReloaded(2))
                {
                    //Illuminate the stapler lights only
                    ControlLED(OFF,RELOAD_LIGHT_2);
                    ControlLED(ON,STAPLER_LIGHT_2);
                }
            }
        }

////////////////
```

```
//third scenario//
/////////////////

     //If ergo is present and is in the process of wreaking havoc
     if (ErgoAlreadyCame && ErgoIsUp())
     {

          /*
          //If the grace period has expired, we can screw with them...
          if((TMRS12_GetTime()-ErgoStartTime) > ERGO_GRACE_PERIOD)
          {

               //Check if player has a staple event
               if(CheckStaplePress(1,Level))
               {
                    //If gotcha flag is low, punish them! ha!
                    if (!P1gotcha)
                    {
                         printf("gotcha, suckaaaaaa whose name is player 1!!!\r\n");

                         //Decrement score
                         P1score = P1score - ERGO_PUNISHMENT;
                         if (P1score < 0)
                              P1score = 5;
                         //Normalize score to feed into setpopup
                         PaperStack1Pos = 100 - (100 * P1score) / HARD_WIN_SCORE;
                         //Move paper stack up
                         SetPopup(PAPER1,PaperStack1Pos);
                         //blink their stapler!
                         ControlLED(BLINK,STAPLER_LIGHT_1);
                         //Gotcha flag goes high
                         P1gotcha = 1;
                    }
               }
               if(CheckStaplePress(2,Level))
               {
                    if (!P2gotcha)
                    {
                         //Decrement score
                         P2score = P2score - ERGO_PUNISHMENT;
```

```
                                        if (P2score < 0)
                                             P2score = 5;
                                        //Normalize score to feed into setpopup
                                        PaperStack2Pos = 100 - (100 * P2score) / HARD_WIN_SCORE;
                                        //Move paper stack up
                                        SetPopup(PAPER2,PaperStack2Pos);
                                        //blink their stapler!
                                        ControlLED(BLINK,STAPLER_LIGHT_2);
                                        //Gotcha flag goes high
                                        P2gotcha = 1;
                                   }
                              }
                         }
                         */
                         //If ergo is done wreaking havoc
                         if((TMRS12_GetTime() - ErgoStartTime) > ERGO_TIME_UP)
                         {
                              //put the management away
                              ManagementAway();
                              printf("ergo retreating\r\n");

                              //relight staplers, turn off ergo light
                              ControlLED(OFF,ERGO_INSTRUCT_LIGHT);
                              ControlLED(ON,STAPLER_LIGHT_1);
                              ControlLED(ON,STAPLER_LIGHT_2);
                         }

                    }
                    break;
               }
               break;
               case POSTGAME:
                    //When the prize has been successfully dispensed, reset the game!
                   if (CheckDispensePrize()){
                        GameStage=RESET;
                        InitRESET();
                   }
                   break;
          }
     }
```

```
static void RunChecks(void)
{
    if (ResetButton() == 1)
    {
        //reset the game
        printf("resetting game now\r\n");
        GameStage = RESET;
    }
    //blink any LEDs that need blinkin'
    BlinkLED();
    //stop any paper stacks that have hit their limit switches
    CheckAllPopupsForArrival();
}

static void InitMAIN(void)
{
    printf("In MAIN initialization sequence\r\n");

    //Initialize a timer with a 1MS time base (each tick = 1ms)
    TMRS12_Init(TMRS12_RATE_1MS);

    //Initialize PWM
    PWMS12_Init();
    //20ms Period
    PWMS12_SetPeriod(0x5096, PWMS12_GRP1);

    // Initializes AD ports
    if(ADS12_Init("OOOOOIIA") != ADS12_OK)
        printf("ERROR: AD Initialization unsuccessful\r\n");
    // Initialize all PORT M Bits as inputs
    DDRM = 0x00;
    // Initialize all PORT T Bits as outputs
    DDRT = 0xFF;

    // Start with all bits off
    PTT = 0x00;
    PTM = 0x00;

    //Calibrate the paper stack motors (not necessary if values are hard-coded in)
```

```
    //CalibratePopup(PAPER1);
    //CalibratePopup(PAPER2);

}

static void InitRESET(void)
{
     printf("In RESET stage\r\n");

     //Set paper stacks to zero
     SetPopup(PAPER1,0);
     SetPopup(PAPER2,0);

     coinInserted = 0;

     //Illumination off
     TurnAllOff();

     //Put management away
     ManagementAway();
}

static void InitWAITCOIN(void)
{
     //printf("In WAITCOIN stage\r\n");

     //Illuminate paycheck slot only
     TurnAllOff();
     ControlLED(BLINK,PAYCHECK_LIGHT);
}

static char CheckCoin(void)
{
     // get current state of coin sensor
     coinInserted = BIT1HI & PTAD;

     // returns 1 if coin has been detected
     return coinInserted;
}
```

```
static void InitWAITSTART(void)
{
     printf("In WAITSTART stage\r\n");

     //Start game timeout timer (timer 7)
//   TMRS12_InitTimer(7,TIMEOUT);

     //Illuminate start light only
     TurnAllOff();
     ControlLED(BLINK,START_LIGHT);
}

static void InitPREGAME(void)
{
     printf("In PREGAME stage\r\n");

     //Paper stacks up
     SetPopup(PAPER1,100);
     SetPopup(PAPER2,100);

     //Set scores to zero
     P1score = 0;
     P2score = 0;

     //Refill staplers
     RefillStaplers();

     //Turn all lights off
     TurnAllOff();
}

static void InitGAME(void)
{
     printf("In GAME stage\r\n");
     //Illuminate staplers only
     TurnAllOff();
     ControlLED(ON,STAPLER_LIGHT_1);
     ControlLED(ON,STAPLER_LIGHT_2);

     //If difficulty is hard, set ergo surprise time
```

```
     if (Level == HARD)
     {
          TMRS12_InitTimer(6, ERGO_TIME);
          ErgoAlreadyCame = 0;
     }
}

static void InitPOSTGAME(void)
{
     char staplerlight;
     char winner;

     printf("In POSTGAME stage\r\n");

     if (P1score > P2score) {
        staplerlight = STAPLER_LIGHT_1;
        printf("PLAYER 1 WINS -> player 1 kicked your ASS, player 2!! \r\n");
        winner = PAPER1;
     }
     else {
        staplerlight = STAPLER_LIGHT_2;
        printf("PLAYER 2 WINS -> player 2 PWNED your lameness, player 1! \r\n");
        winner = PAPER2;
     }

     //Flash winner's stapler light
     TurnAllOff();
     ControlLED(BLINK,staplerlight);

     //Boss emerges
     SetServoAngle(BOSS_ANGLE);

     //Initialie the prize dispension
     InitDispensePrize();
}

//returns true if either player has exceeded the winning score
static char IsWinner(void)
{
    int winningScore;
```

```
    //set the winning score based on the selected level
    switch(Level)
    {
        case EASY: winningScore = EASY_WIN_SCORE; break;
        case MEDIUM: winningScore = MEDIUM_WIN_SCORE; break;
        case HARD: winningScore = HARD_WIN_SCORE; break;
    }

    //return true if one of the players has won
    if((P1score >= winningScore) || (P2score >= winningScore))
        return TRUE;

    return FALSE;
}

//The main TESTING function
#ifdef TEST
void main(void)
{
     //Perform main initialization sequence
     InitMAIN();

     /*
     //Test coin sensor
     printf("Please insert a coin\r\n");
     while (!CheckCoin());
     printf("Coin check: CHECK!\r\n\r\n");

     //Test the level selection
     printf("Please select a level and hit start\r\n");
     LevelTest();
     printf("Level check: CHECK!\r\n\r\n");

     //Test the servo
     printf("Servo test beginning...");
     Wait(1000);
     printf("NOW!\r\n");
     ServoTest();
     printf("Servo check: CHECK!\r\n\r\n");
```

```
    //Test paper stacks
    printf("Paper stack test beginning...");
    Wait(1000);
    printf("NOW!\r\n");
    PopupTest(PAPER1);
    PopupTest(PAPER2);
    //Test stapler 1 for input
    printf("\r\n Start stapling...");
    Wait(3000);
    printf("NOW!!!!!\r\n");
    StaplerTest();
    printf("Staple check: CHECK!\r\n\r\n");
    //Test the reload functionality
    printf("Please reload the stapler\r\n");
    ReloadTest();
    printf("Reload check: CHECK!\r\n\r\n");
    //Test all LEDs
    printf("LED test beginning...");
    Wait(1000);
    printf("NOW!\r\n");
    LEDTest();
    printf("LED check: CHECK!\r\n\r\n");
    //Test prize dispensing ability
    printf("Prize dispensing test beginning...");
    InitDispensePrize();
    while(CheckDispensePrize() == 0);
    printf("Prize check: CHECK!\r\n");

    Wait(500);
    printf("\r\nTesting complete! Have a nice life!\r\n");
    return;
}
#endif
```

Servo.h

```
#ifndef SERVO
#define SERVO

//constant definitions
#define MAX_SERVO_ANGLE 90 //the max degrees of travel the servo can go
#define MIN_SERVO_DUTY 5 //the pwm that will put the servo at its min angle
#define MAX_SERVO_DUTY 10 //the pwm that will put the servo at its max angle
#define BOSS_ANGLE 90        //angle of servo that will pop up boss
#define ERGO_ANGLE 0       //angle of servo that will pop up ergonomist

//FUNCTION PROTOTYPES
void ServoTest(void);
void SetServoAngle(int angle);
void ManagementAway(void);
char ErgoIsUp(void);
static int ConvertAngleToDUTY(int angle);

#endif
```

Servo.c

```
//INCLUDES
#include "headers.h"
#include "servo.h"

static char ergoUp = 0;

void ServoTest(void)
{
    short i;
    for(i=0;i<=MAX_SERVO_ANGLE;i=i+5)
    {
        SetServoAngle(i);
        //kill some time
        Wait(100);
    }
    while(TRUE) {
        printf("BOSS \r\n");
        SetServoAngle(BOSS_ANGLE);
        //kill lots of time - it takes awhile for the motor to move, and we don't want to cut it off
        Wait(5000);
        SetServoAngle(ERGO_ANGLE);
```

```
        printf("ERGO \r\n");
        Wait(5000);
    }
}

void SetServoAngle(int angle)
{
    //PWM grp1 period already set to 20ms in main initialization
    int duty;

    duty = ConvertAngleToDUTY(angle);
    //printf("duty cycle: %d\r\n",duty);

    if (angle == ERGO_ANGLE) ergoUp = 1;
    else ergoUp = 0;

    PWMS12_SetDuty((char) duty, PWMS12_CHAN2);
}

//Converts an angle to a duty cycle using info from the servo data sheet
static int ConvertAngleToDUTY(int angle)
{
    return (MIN_SERVO_DUTY*100 +
    (MAX_SERVO_DUTY-MIN_SERVO_DUTY) *
    (angle*100 / MAX_SERVO_ANGLE))/100;
}

char ErgoIsUp(void)
{
    return ergoUp;
}

void ManagementAway(void)
{
    int duty;
    ergoUp = 0;

    duty = (MIN_SERVO_DUTY + MAX_SERVO_DUTY)/2;
    PWMS12_SetDuty((char) duty, PWMS12_CHAN2);
}
```

Stapler.h

```
#ifndef STAPLER
#define STAPLER

//FUNCTION PROTOTYPES
void StaplerTest(void);
void ReloadTest(void);
char CheckStaplePress(int playerID, char level);
char HasReloaded(int playerID);
char IsAmmoLeft(int playerID);
static char CheckStapler(int playerID, char staplerState);
static void UsedAStaple(int playerID);
void RefillStaplers(void);

#endif
```

Stapler.c

```
/*OUTPUTS:
T6 - Reload light 1
T7 - Reload light 2
AD3 - Stapler light 1
AD4 - Stapler light 2
*/

#define STAPLER_CAPACITY 20 //number of staples that a stapler can hold

//INCLUDES
#include "headers.h"

static int P1staples = STAPLER_CAPACITY; //number of staples in player 1's stapler
static int P2staples = STAPLER_CAPACITY; //number of staples in player 2's stapler
static int stapler1down = 0;
static int stapler2down = 0;
static int player1needsreload = 0;
static int player2needsreload = 0;
static int player1hasopened = 0;
static int player2hasopened = 0;
static int player1hasclosed = 0;
static int player2hasclosed = 0;
```

```
void StaplerTest(void)
{
int score = 0;
//goes for specific amount of time
    TMRS12_InitTimer(0,1000);
    while(TMRS12_IsTimerExpired(0) != TMRS12_EXPIRED)
    {
        if (!player1needsreload)
        {
            if (CheckStaplePress(1, MEDIUM)) score++;    //checks stapler for staple events
        }
    }
    //prints number of staples sensed
    printf("Number of staples sensed is %d\r\n",score);
}

void ReloadTest(void)
{
    player1needsreload = 1;
    while(!HasReloaded(1));
}

char CheckStaplePress(int playerID, char level)
{
    //switch for each player:
    switch (playerID)
    {
        case 1:
    //if stapler is down and current state is 0
            if ((PTM&BIT0HI) && !stapler1down)
            {
                stapler1down = 1;       //set current state to 1
                if (level > EASY) UsedAStaple(1);
                printf("stapler 1 just got pressed!\r\n");
                return 1;
            }
    //if stapler is not down and current state is 1
            else if (!(PTM&BIT0HI) && stapler1down)
            {
                stapler1down = 0;       //set current state to 0
```

```
                //printf("stapler 1 just got released!\r\n");
            }
        return 0;

        case 2:
    //if stapler is down and current state is 0
            if ((PTM&BIT1HI) && !stapler2down)
            {
                stapler2down = 1;       //set current state to 1
                if (level > EASY) UsedAStaple(2);
                printf("stapler 2 just got pressed!\r\n");
                return 1;
            }
    //if stapler is not down and current state is 1
            else if (!(PTM&BIT1HI) && stapler2down)
            {
                stapler2down = 0;       //set current state to 0
                //printf("stapler 2 just got released!\r\n");
            }
        return 0;
    }
}

char HasReloaded(int playerID)
{
    //switch for each player:
    switch (playerID)
    {
        case 1:
            if (player1needsreload)
            {
                //check for stapler opening
                if (!player1hasopened) player1hasopened = CheckStapler(1,OPEN);
                //check for stapler closing
                if (!player1hasclosed && player1hasopened) player1hasclosed = CheckStapler(1,CLOSED);
                //if both conditions have been satisfied
                if (player1hasopened && player1hasclosed)
                {
                    //refill the stapler
                    P1staples = STAPLER_CAPACITY;
```

```
                    //reset all reload-related states
                    player1needsreload = 0;
                    player1hasopened = 0;
                    player1hasclosed = 0;
                    return 1;
                } else return 0;
            }

        case 2:
            if (player2needsreload)
            {
                //check for stapler opening
                if (!player2hasopened) player2hasopened = CheckStapler(2,OPEN);
                //check for stapler closing
                if (!player2hasclosed && player2hasopened) player2hasclosed = CheckStapler(2,CLOSED);
                //if both conditions have been satisfied
                if (player2hasopened && player2hasclosed)
                {
                    //refill the stapler
                    P2staples = STAPLER_CAPACITY;
                    //reset all reload-related states
                    player2needsreload = 0;
                    player2hasopened = 0;
                    player2hasclosed = 0;
                    return 1;
                } else return 0;
            }
    }
}

//refill both staplers
void RefillStaplers(void){
    P2staples = STAPLER_CAPACITY;
    P1staples = STAPLER_CAPACITY;
    player1needsreload = 0;
    player2needsreload = 0;
}

static char CheckStapler(int playerID, char staplerState)
{
```

```
switch(playerID)
{
    case 1:
        switch(staplerState)
        {
            case OPEN:
            //if stapler is open and this is a new thang
            if ((PTM&BIT2HI) && !player1hasopened)
                {
                    player1hasopened = 1;       //player 1 has opened stapler
                    printf("stapler 1 just got opened!\r\n");
                    return 1;
                } else return 0;
            case CLOSED:
            //if stapler is closed and this is a new thang
            if (!(PTM&BIT2HI) && !player1hasclosed)
                {
                    player1hasclosed = 1;       //player 1 has closed stapler
                    printf("stapler 1 just got closed!\r\n");
                    return 1;
                } else return 0;
        }
    case 2:
        switch(staplerState)
        {
            case OPEN:
            //if stapler is open and this is a new thang
            if ((PTM&BIT3HI) && !player2hasopened)
                {
                    player2hasopened = 1;       //player 2 has opened stapler
                    printf("stapler 2 just got opened!\r\n");
                    return 1;
                } else return 0;
            case CLOSED:
            //if stapler is closed and this is a new thang
            if (!(PTM&BIT3HI) && !player2hasclosed)
                {
                    player2hasclosed = 1;       //player 2 has closed stapler
                    printf("stapler 2 just got closed!\r\n");
                    return 1;
```

```
                    } else return 0;
            }
    }
}

static void UsedAStaple(int playerID)
{
    switch(playerID)
    {
        case 1:
        if (P1staples <= 1)
        {
            player1needsreload = 1;
            break;
        } else
        {
            P1staples--;
            break;
        }
        case 2:
        if (P2staples <= 1)
        {
            player2needsreload = 1;
            break;
        } else
        {
            P2staples--;
            break;
        }
    }
}

char IsAmmoLeft(int playerID)
{
    if (playerID == 1) return !player1needsreload;
    if (playerID == 2) return !player2needsreload;
}
```

Headers.h

```
#ifndef HEADERS
#define HEADERS

//All of the headers needed for mystapler!

//Proven code
#include <stdio.h>
#include <ME218_C32.h>
#include <timers12.h>
#include <PWMS12.h>
#include <ADS12.h>

//Our code
#include "play.h"
#include "stapler.h"
#include "paper.h"
#include "servo.h"
#include "interface.h"
#include "LED.h"
#include "helpers.h"

#endif
```

Appendix B

BOM

Category	Item	Description	Quantity	Price
Electronic	2N7000	N-channel mosfet	6	$0.50
	LM239B	Motor driver chip	2	$2
	74HC14	Hex inverter	1	$1
	LM339	Comparetor	1	$1
	Potentiometer	10K Potentionmeter	1	$3
	DC Motor	Geared DC motor	4	$6
	Tape sensor	Used for staplers	2	$2
	Coin Sensor	Senses pennies	1	$2
	Limit Switch	Limit switch with lever	4	$1.50
	LED	Varying colors	50	$0.20
	Button	Start button	1	$3
	Servo	For boss/ergo	1	$15
	Molex	Connectors of diff sizes	20	$0.30
	Diodes	For preventing V spikes	10	$0.05
	Resistors	Various values	100	$0.01
	Capacitors	Various values	5	$0.10
Mechanical	Stapler	Swingline, red	2	$20
	Acrylic	Multi colored	1	$20
	Masonite	Brown	1	$15
	Foam core	Red	1	$5
	Fasteners	Various	30	$0.05
	Foam wheels	Foamy	4	$2
Decorative	Inbox	from ikea	1	$4.50
	Paper	for graphics	1	$10
	Veneer	Wood, looks cheesey	1	$5
	Mug	DFS	1	$3
	Tape	Scotch	1	$3
	Post-its	Multi-colored	1	$5
	Business Cards	Customized	500	$0.01
	Felt	Grey	1	$5
		TOTAL		**$214.00**