OPERATOR’S MANUAL

HEAD-MOUNTED & ARM-MOUNTED ART DESIGN SYSTEM

NSF SPONSORED PROJECT

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IMPORTANT SAFETY INSTRUCTIONS

THE SYSTEMS CAN RELIABLY MAKE SQUIGGLE DESIGNS WHEN USED PROPERLY. PLEASE READ THE APPROPRIATE SECTIONS OF THE HEAD-MOUNTED AND ARM-MOUNTED ART DESIGN SYSTEMS OWNER’S MANUAL THOROUGHLY BEFORE USE.

➢ Do not tamper with the eyeblink transmitter or receiver. Any tampering with the contents of these devices may damage the quality of the eyeblink processing.

➢ Do not leave the systems powered on when they are not in use. This will drain the batteries of their charge.

➢ Only insert the appropriate rechargeable AA batteries into their docks.

➢ Be sure that fingers are clear of any moving parts.

➢ Keep water away from the electrical components.

➢ Keep water away from the battery power source and motor.

➢ When recharging battery first connect the battery to the charger and then plug the charger into the wall socket. *DO NOT PLUG IN THE CHARGER FIRST AND THEN CONNECT THE BATTERIES.

➢ Do not cut or tamper with electrical wires.

➢ Do not disassemble the soft switch that contains electrical components and wires.

➢ Do not overtighten the head and arm adjustments. Doing so may affect circulation.

➢ Be sure to tighten the adjustable knob at the back bottom of the helmet. Not doing so will result in possible injury to the user.

➢ Keep loose articles of clothing, paper, or any miscellaneous items away from all moving parts.

➢ Always make sure device is off before entering/exposing the interior of the device.
**Parts & Accessories**

The following parts and accessories are included with the Head and Arm-Mounted Art Design Systems:

1. **Black Adjustable Wrist Piece**

2. **Yellow Adjustable Hard Hat**

3. **Powerizer AA Rechargeable Batteries**

4. **Energizer Battery Charger**
5. **Soft Switch (2)**

6. **Adjustable Compass (2)**

7. **Gooseneck and Speedometer Cables**
8. **EYEBLINK SWITCH CIRCUIT AND ENCASEMENT**
9. **EYEGlasses with Mounted Eyeblink Sensors**
FEATURES

THE HEAD & ARM-MOUNTED ART DESIGN SYSTEMS OFFER A VARIETY OF USEFUL FEATURES FOR ALLOWING PEOPLE WITH LIMITED MOTOR SKILLS TO DRAW.

SUCH FEATURES INCLUDE:

- Innovative Eyeblink Sensor to power on/off the devices
- Flexible, yet rigid design
- Lightweight structuring
- Adjustable to multiple users’ arm and head sizes
- Reversible motor
- Durable and mobile
- Safety Features include caretaker overiding switches
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1. INTRODUCTION:

1.1 GENERAL OVERVIEW OF THE DEVICE:

The Head and Arm Mounted Art Design systems are devices that will assist people with limited motor skills in reaching their maximum artistic potential. The goal is to amplify the user’s minimal motor functions by creating two devices that will aid them in drawing and painting endeavors. These devices will be created be adjustable so that both devices may be used by other artists in an art studio with similar mobility situations.

The first system, the Head Mounted Art Design System, is specifically created with the independence of the user in mind. It consists mainly of a gooseneck arm, soft switch, eye glasses with infrared eye blink sensors, an adjustable helmet, and a rotating compass with an art utensil holder so that the user may alternate between any artistic media. This is the main device that will assist the user to be entirely independent of any aids.

The second system, the Arm Mounted Art Design System, will be composed of a simple wrist cuff, a shorter gooseneck, soft switch, and glasses with infrared eye blink sensors. The Arm Mounted System will aid in the user’s artwork when they get tired of wearing the headpiece, or desire a slightly more mobile system.

The head gooseneck arm fits on the adjustable helmet. This may be rotated or flexed in any desired position, to reach a desk or to reach a canvas on an easel. This is shown below:

![Helmet Side View with Gooseneck Connection](image)

**Figure 1: Helmet Side View with Gooseneck Connection**
A rotating speedometer cable runs through the gooseneck and rotates the adjustable compass. The other side of the cable is rotated by the small 12 volt DC motor. These are all attached to each other by simple set screw and round rod aluminum configurations.

Figure 2: All Headpiece Connections

The compass may be widened to adjust to any size squiggle that the user desires it to be. Also, there is a plastic piece located on this compass that may be turned to fit any size art utensil ranging from a small brush to a moderate size marker.

Figure 3: Adjustable Compass

The 12 volt motor is rotated by AA powerizer batteries. These battery packs may be found on the inner side of the system box.
This motor may be reversed by the simple touch of the soft switch. Touch it once and it turns in one direction. Touch it again and it reverses. This is made of foam and sturdy PVC plates, so this can withstand any forces that a person with limited mobility can subject it to.

To turn the motor on or off, the user has two options of this. The first option is to simply use the on/off over-riding caretaker switch. This is the red button located on the side of the box. In addition to this, there is an infrared eyeblink sensor switch that senses when the user blinks purposefully for more than one second. These are mounted to a pair of eyeglasses and should be pointed towards the corner of the subject's eyes'. Both these switches are attached in the main project box.

![Figure 4: Soft Switch to Reverse the Motor](image)

![Figure 5: Glasses With Eyeblink Sensor](image)

![Figure 6: Caretaker Overwriting Switch](image)

The arm mounted systems contain similar components as the head mounted art design system. These include the gooseneck, speedometer
cable, and adjustable compass. Also, all the switches and eyeblink switch glasses are the same. The only differentiation between the two is how it is mounted. The arm mounted system uses an arm brace to wrap around the user’s arm. This is able to adjust to multiple size wrists by varying the location of the Velcro. The gooseneck is run along its length and then the rotating cable is put inside it.

![Figure 7: Adjustable Arm Brace](image)

All the electrical connections are run into and out of the project box shown below (Figure 9). The motor is attached on the side of the box through a metal piece. The soft switch (red, black, and white braided wire) is attached across the motor connections within the box. The eyeglass with eyeblink sensor (white braided wire) is hooked into 4 small holes located right next to the smaller LM 339 chip on the PC Board. The motor is connected to the speedometer cable through the use of an aluminum piece and three 4-40 set screws.

![Figure 8: All Arm-Mounted Connections](image)
Lastly, there is an Energizer rechargeable battery charger included in the project. This is a free-standing device that needs only to be used when the batteries need charging. This battery charger can charge the AA batteries provided as well as 9 V and AAA.

1.2 **STEP BY STEP INSTRUCTIONS:**

**FOR THE HEAD-MOUNTED SYSTEM:**

1. Place the helmet over the user's head.
2. Adjust the knob on the back of the helmet to fit snugly. Press in and then turn the knob.


4. Put on eyeglasses.

5. Open up the adjustable compass piece.

6. Place in utensil the user wishes to use.

7. Tighten the mechanism around the utensil to ensure that it stays in place.
8. Position the gooseneck and the compass to reach the paper location desired. Make sure to have the compass at a 90 degree angle to the paper.

9. Place the soft switch in a position that will be easy for the user to press down upon.

10. Open/close up the compass to reach the circle size desired.

11. Blink purposefully for one second. The system should now power on.
12. Reposition the compass to reach all positions on the page desired.

13. To change the direction of the compass movement, press down on the black soft switch. The squiggles should now be following the opposite direction.

14. To make fun squiggle patterns, continuously press on the soft switch to constantly change the direction of the motor and the direction of the squiggles.

15. To turn off the device, blink purposefully for one second.

16. If the caretaker would like to power on or off the systems themselves, they may flip the switch found on the black box.

17. Take off all systems carefully and slowly.

18. Store in a clean storage room that is not overexposed to heat or moisture or person tampering.

FOR THE ARM-MOUNTED SYSTEM:

1. Place the arm brace over the user’s arm.
2. Make sure that the gooseneck is on the bottom side of the person’s arm and that the top Velcro piece goes around the user’s hand over the thumb.

3. Loop both Velcro pieces through the silver loops.

4. Velcro straps in comfortable position.

5. Put on eyeglasses.

6. Open up the adjustable compass piece.

7. Place in utensil the user wishes to use.

8. Tighten the mechanism around the utensil to ensure that it stays in place.
9. Position the gooseneck and the compass to reach the paper location desired. Make sure to have the compass at a 90 degree angle to the paper.

10. Place the soft switch in a position that will be easy for the user to press down upon.

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2. MAINTENANCE:

ENVIRONMENTAL:

- Do not expose the project boxes or any of the other parts to water. This device is not water proof. If exposed to water the device will be damage and should not be turned on after for safety reasons.

- The device should not be exposed to high temperatures. This may cause damage to the device.

- The device should not be exposed to extreme cold. That could damage it as well.

- The device should be used in room temperature.

ELECTRICAL:

INITIAL CALIBRATION OF EYE BLINK MECHANISM

The switch works by registering eye blinks. The size of the detector is \( \frac{3}{4} \) inch length by \( \frac{1}{4} \) inch diameter. The distance of the sensor to the eye should be 0.75 to 1 inch away from the corner of the user’s eye as seen above in the instructional section. If the sensor comes within a distance of 0.5 inches or closer from the eye then the signal gets saturated, and it will read the signal as the user purposefully blinking nonstop.

Once the system have been properly configured, the detector will sense a purposeful eye – blink which will then get processed into mechanical motion and turn the system on or off. When eye is open the IR sensor is saturated with a 5V output. When close to the eye, nothing is registered so the reflection back so voltage drops to 0V.

Important!
Do not make exaggerated blinks, only make smaller blinks
The comparator compares one voltage to another and we put a voltage divider on one pin and set it below when the eye is open from the IR circuit.
Figure 11: Do NOT Need to Make Overexaggerated blink (Scrunch Face Up)

- Do not expose the boxes to static electricity. The electrical components within the boxes are very sensitive to this type of electricity and you could possibly damage them.

- Do not expose extreme heat to the QRD infrared sensor. Doing so may damage its effectiveness.

- Do not bend any electrical wires at the points of their attachment. This may damage the wire and cause it to break. This would entail the user having to resolder the wires back into their proper positions.

Maximize battery performance

- Do not short circuit the battery
- Do not hit, drop or abuse in any way
- Do not expose the batteries to water
- Keep the batteries away from extreme heat otherwise the cell might overhead and explode
- First time battery charging
  - Batteries may say they are fully charged in 10 or 15 minutes but in reality they are not “broken in” yet so need overnight charging or a time period of twelve hours.
  - It is normal for a battery to become warm during the first charging and discharging.
  - A new battery needs to fully charge for the first two to four times. This will allow for the battery to reach the maximum rated capacity.
- Keep batteries Clean
  - On a biweekly basis, clean the dirty battery contacts with a cotton swab and alcohol. Doing this will maintain a great connection between the switch and the eye blink device.

- Use the Battery
  - Leaving a battery unused for long time periods will reduce battery performance. Use a minimum of one time every two weeks.

- Storing Batteries
  - If the intention is to not use the Head & Arm art mounted systems, then store the batteries in a cool, dry and clean place. Make sure this area is away from heat and metal objects.
  - NiMH batteries has a very low self discharge that occurs during the storage time, but remember to recharge the batteries before usage.

Replacement of Batteries

1. Turn off the power to the system by turning off the main caretaker overriding switch. The off position is denoted by “O” on the head mounted system, and by the blank position on the arm-mounted device.
2. Open up the top of the project box by removing the 4 corner screws by a Philips screwdriver. This can be seen in the above figure.
3. Flip open the lid and remove far enough away from the box so that the user does not put excessive stress on the wires that connect the batteries to the main PC Board. Make sure to do this slowly as well.

4. Carefully remove the batteries that need to be recharged. This requires a bit of effort, so be take caution of not using excessive force upon the battery removal.
5. Place the battery into the appropriate positions in the Energizer battery recharger. There are only 4 places for the AA batteries. Do not place them in any other positions than as shown above. Also, do not charge different battery types at once-only charge AA with AA batteries. Lastly, make sure to position the batteries facing the correct + and − positions indicated in the Energizer Recharger. The photo above shows this correct positioning. Do NOT plug in the charger before placing in the batteries.

6. Close the lid.

7. Plug in the charger.
8. When the batteries are charging, the lights on the Energizer charger should be the red color as shown above. For a first time battery charge, the battery takes approximately 8 hours to charge. Subsequent charges only take about 45 minutes.

**MECHANICAL:**

- Do not severely twist or misshape the gooseneck, for it may cause permanent damage to the speedometer cable within.

- If failure of simple components occurs (for example screws, nuts, brackets), obtain similar sized parts at your local hardware stores.
LUBRICATING THE INNER SPEEDOMETER

After constant use of both the Head and Arm Mounted Art Design Systems, the user may notice that the rotational device does not turn as well. If it feels like it is “catching” on something, the proper maintenance for this requires that the inner speedometer cable be mildly lubricated with grease or oil.

The motor to speedometer connection is shown above. The metal piece in between the two parts needs to be removed for proper lubrication. To do this, a small Allen wrench must be used to unscrew the 4-40 set screws.

Once this is removed, carefully remove the speedometer cable by pulling on the compass end of it. The inner speedometer cable is gold in color and should look like a tightly rolled spring. Lubricate the section that comes in contact with the flexible gooseneck tubing, and then replace it back to its original position and connection, once again using the Allen wrench.

CLEANING THE INSIDE OF THE ELECTRICAL BOX

- Turn the switch to the off position.
- Using a piece of soft cloth and mild surface cleaner, gently wipe the dirty area of the case.
- Dry the cleaned area with a soft cloth.
3. TECHNICAL DESCRIPTION:

Figure 12: PCB Layout

The above circuit is comprised of many components namely:

✓ PIC 16F874 (1)
- LM 339 (1)
- 22 PF capacitors (2)
- 2200UF capacitor (1)
- 100 UF capacitor (1)
- 10K Ohm resistor (1)
- 100 Ohm resistors (2)
- 100K Ohm resistor (2)
- 4MHz resonator
✓ QRD 1114 (eye blink sensor)

✓ 7805 positive voltage regulator
At this point, each component will be reviewed closely and its functionality in the whole system will be explained:

Please note: All test connections are shown with a large square white dot at the two test points. You can use this as reference to make sure you are making the right connections during testing.

**PIC16F874:**
The PIC is a programmable microcontroller which is the main component of the system. It basically is programmed so as to separate the normal blinks to the purposeful 2 second blink. The manufacturer of this chip is MicroChip® and it was programmed using MPLab which is also a MicroChip® program.

The functionality of this device can only valid if all of the following tests have been passed:

- While in the system, set a digital multi-meter between ground and the first pin of the PIC. The first pin on the PIC is shown in the above diagram.
Using an oscilloscope have one end go to ground and the other to pin 26. When the system is turned on the signal will go high. Remember: the signal will only turn on if a purposeful eye-blink of 2 seconds is made.
The following website can be used to buy the part:
www.newark.com

LM339:

This chip is a voltage comparator chip and is used to compare different voltages that are obtained when a different blinking action is carried out. There is a voltage on the chip when there is a purposeful blink and when there is a normal blink.
The functionality of this device can be checked by the following tests:

- Using a digital multi-meter connect pin 3 on one end and ground on the other. 5V should appear.
Using a digital multi-meter connect pin 12 on one end and ground on the other. 0V should appear.
Using an oscilloscope, connect one end to pin 11 and the other end to ground, every eye blink will should go to a high and immediately fall back to a low.
This chip can be found at www.newark.com
4MHz resonator

The resonator can be tested by placing an oscilloscope at ground on one end and one of the end pins of the resonator. A continuous pulse should be seen on the scope.
7805 positive voltage regulator

The voltage regulator can be tested by the following methods; it is fully working only if all of these tests are met:
Place one end of the digital multi-meter on the left most PIN (in pin, as shown in the above diagram) and the other end to ground. It should read 10volts (+/- 2volts).
✓ Using a digital multi-meter connect middle pin on one end and ground on the other. 0V should appear.
Using a digital multi-meter connect the out pin (as shown in the diagram above) on one end and ground on the other. 5V should appear.
This part can be ordered at Newark.com
The MOSFET can be checked for functionality by placing one end of a digital multimeter at ground and the other end at the drain, which is the middle pin as shown in the picture below. The MOSFET acts as a motor driver and when a voltage of 5V comes through, it starts the motor.
N-CHANNEL ENHANCEMENT MODE

TERMINAL DIAGRAM

TERMINAL DESIGNATION
It can be purchased at newark.com

Motor:

The motor specifications are as follows:

- Slow speed and high torque
- DC reversible gear trains
- Motor housing 1-13/16" L x 1-13/16" O.D.
- Steel shaft
- Diameter x 11/16" L
- Weighs approx. 2 3/4 oz.
- No-load drain Approximately 8mA at 12V
- Continuous run, low temp
A motor with such specifications can be found at any electronic online store.

Resistors and Capacitors:

To check resistors and capacitors, connect both ends to the multi-meter ends and make sure that the value is as specified earlier.

QRD 1114 - eye blink sensor
The following are ways to make sure that the sensor is working correctly:

- Using a digital multi-meter, connect one end to pin 2 and the other to pin 4, 0V should be seen on the multi-meter.
- Make sure that both the white strips in the above picture are on one level. One is a sensor and other is a receiver they need to be in the same depth to work collaboratively.

4. TROUBLESHOOTING:

- **PROBLEM 1:**
  After turning the switch on, there is no voltage going through
  - POSSIBLE CAUSE:
    - Dead batteries
  - HOW TO FIX IT
    - Turn switch off, recharge batteries, and turn it back on. If still not working, it means that something is damaged.

- **PROBLEM 2**
  System will not turn on
  - POSSIBLE CAUSE 1:
    - System is not powered
  - HOW TO FIX IT 1:
    - Verify that the system's batteries are properly placed. If so, verify that the power cable has been properly connected to the motor
**POSSIBLE CAUSE 2:**
System not properly sensing the purposeful eyeblinks

**HOW TO FIX IT 2:**
Place sensor on glasses closer to the user’s eyelid to ensure proper detection of purposeful eyeblink

➤ **PROBLEM 4**
Head piece is falling over.

**POSSIBLE CAUSE:**
Head piece is too loose

**HOW TO FIX IT**
Press the knob on the back of the helmet in and then rotate to the right to tighten it.

➤ **PROBLEM 5**
Head piece is falling off user.

**POSSIBLE CAUSE:**
Chin strap too frayed/damaged

**HOW TO FIX IT**
Replace with a regular chin strap found on most bicycle helmets sold in stores.

➤ **PROBLEM 6**
Arm piece is falling off user.

**POSSIBLE CAUSE:**
Arm piece is too loose.

**HOW TO FIX IT**
Check the Velcro connections on the arm piece. If this does not help, the arm piece may have been permanently deformed to be too large.

➤ **PROBLEM 7**
Compass does not rotate.

- **Possible Cause 1:** Speedometer cable may be stuck on one of its coverings.
  
  - **How to Fix It 1:** Gently pull at the rotating piece at its exposed locations while the device is off. Rotate it until it becomes free of debris.

- **Possible Cause 2:** Speedometer cable may not be lubricated sufficiently.
  
  - **How to Fix It 1:** Lubricate according to the manual description in the maintenance section.

**Problem 8**
Compass does not hit paper properly.

- **Possible Cause 1:** Compass is poorly positioned.
  
  - **How to Fix It 1:** Realign gooseneck so that the compass approaches the paper or canvas at a 90 degree angle.

- **Possible Cause 2:** The art utensil may be over or underpositioned.
  
  - **How to Fix It 2:** Readjust for the art utensil tip to be aligned with the other end of the compass with the ball bearing. Make sure that both parts of the compass are touching the paper equally without favoring any one side.

**Problem 9**
Motor is not reversing
Possible Cause:
The connection between the push button switch and the wire might be loose.

How to Fix It:
First slightly open the threaded seam of the soft switch. Then have a qualified electrical service person check the connections of the soft switch to the motor box, and make sure that all the check all electrical connections are proper.
PROBLEM 10
Device making abnormal noises or emitting smells

- **POSSIBLE CAUSE:**
  System may be overheating.

- **HOW TO FIX IT:**

```plaintext
(1 \rightarrow 6) 1
motor \leftarrow 2
(3 \rightarrow 4) 3

4 (4 \rightarrow 3)
5 \rightarrow motor
6 (6 \rightarrow 1)
```
Turn off the system immediately and replace all suspicious parts.

➢ **PROBLEM 11**
The device is uncomfortable to wear

- **POSSIBLE CAUSE:**
  The neoprene fabric is bunched up

- **HOW TO FIX IT:**
  Take device off and see that all the fabrics are smoothly laid out, without any ridges or bumps.

➢ **PROBLEM 12**
The motor is on but the system is not rotating

- **POSSIBLE CAUSE:**
  The motor to rotating cable connection might be loose.

- **HOW TO FIX IT**
  Carefully unscrew the circuit box from the top along with the aluminum plate. Then observe the connection.
Figure 13: How to Disassemble Circuit Box
PROBLEM 13
The eyeblink switch does not activate the system.

- **POSSIBLE CAUSE 1:**
  There may be a connection problem.

  **HOW TO FIX IT 1:**
  Check the wires coming out of the IR sensor and those connected to the inside of the box. Resolder them if it is needed.

- **POSSIBLE CAUSE 2:**
  There may be wires touching each other where they are not supposed to be.

  **HOW TO FIX IT 2:**
  Relocate the wires so that they do not touch each other anymore.

- **POSSIBLE CAUSE 3:**
  The sensor may not be facing the user's eye correctly.

  **HOW TO FIX IT 3:**
  Reposition the sensor so it points at the corner of the user's eye as shown in the instructional section.

PROBLEM 14
The compass ball is not rolling smoothly

- **POSSIBLE CAUSE:**
  Dirt is trapped under the ball

- **HOW TO FIX IT:**
  Use a soft cloth and roll the compass gently over the cloth until the dirt has been removed. Do not use a cloth which is not clean or has loose fibers which could cause a greater obstruction in the movement of the compass.
Figure 14: Dirt particles stuck in ball bearing

Figure 15: Use soft cloth without loose fibers

Figure 16: Roll ball over cloth

PICTURE FOR THE HELEMT IS UNCOMFORTABLE TO WEAR
Figure 17: Forehead Band on Helmet

Figure 18: Forehead strap with lathes
Figure 19: Take out strap and straighten

Figure 20: Position the straightened neoprene under forehead strap
Figure 21: Fold over straps over latches so neoprene band stays in place

Distance between must be between .75 and 1"