

## Homework 12: Ethical and Environmental Impact Analysis

*Due: Friday, April 11, at NOON*

Team Code Name:     The Two Wheel Deal     Group No.     12    

Team Member Completing This Homework:     Eric Geier    

e-mail Address of Team Member:     edgeier     @ **purdue.edu**

NOTE: This is the last in a series of four “professional component” homework assignments, each of which is to be completed by one team member. The completed homework will count for 20% of the individual component of the team member’s grade. The body of the report should be 3-5 pages, **not** including this cover page, references, attachments or appendices.

### Evaluation:

SCORE	DESCRIPTION
10	<i><b>Excellent</b> – among the best papers submitted for this assignment. Very few corrections needed for version submitted in Final Report.</i>
9	<i><b>Very good</b> – all requirements aptly met. Minor additions/corrections needed for version submitted in Final Report.</i>
8	<i><b>Good</b> – all requirements considered and addressed. Several noteworthy additions/corrections needed for version submitted in Final Report.</i>
7	<i><b>Average</b> – all requirements basically met, but some revisions in content should be made for the version submitted in the Final Report.</i>
6	<i><b>Marginal</b> – all requirements met at a nominal level. Significant revisions in content should be made for the version submitted in the Final Report.</i>
*	<i><b>Below the passing threshold</b> – major revisions required to meet report requirements at a nominal level. <b>Revise and resubmit.</b></i>

\* Resubmissions are due within **one week** of the date of return, and will be awarded a score of “6” provided all report requirements have been met at a nominal level.

### Comments:

## **1.0 Introduction**

The Two Wheel Deal is a self-balancing, personal transportation device that is battery powered and driven using two high-speed motors. It works on the control theory principle of the inverted pendulum [1]. This way to accelerate or decelerate the rider simply needs to lean forward or backward respectively. It can be navigated using a joystick near the handlebars. The Two Wheel Deal is meant to serve as a practical and economical alternative to many forms of short distance transportation. Since it has a footprint no larger than a standard wheelchair it can be used practically anywhere.

As with any new or old product, there are ethical and environmental concerns that must be considered before releasing the product to the public. The first and foremost ethical concern regarding the Two Wheel Deal is the safety of the rider. Since this is a transportation vehicle that can move at speeds up to 10 mph, there are many ways that the rider could seriously injure himself/herself. Decisions to be considered are the placement of warning labels, extensive testing in a variety of environments, user training and documentation, and safety mechanisms. There are environmental concerns to consider as well. In the production stage of the product the PCBs, batteries, electronic components, and motors all produce environmental pollution during their creation. During the normal use stage of the product, the batteries present a potential environmental hazard, and during the disposal stage of the product many of the components and parts listed above have special disposal or recycling needs.

## **2.0 Ethical Impact Analysis**

As previously mentioned there are a variety of ethical concerns that need to be considered before releasing the Two Wheel Deal to the public. A helpful guideline when considering engineering ethics is to refer to the Institute of Electrical and Electronics Engineers (IEEE) Code of Ethics [2]. The first major ethical concern is to ensure the Two Wheel Deal has been tested in a variety of environments. Since this is a transportation vehicle a variety of terrains must be considered such as grass, pavement, concrete, gravel, and dirt just to name a few. This problem would be addressed by trying the Two Wheel Deal on these different terrains and seeing how the vehicle reacted. The results and recommendations on how to traverse these environments would be gathered and placed in the user manual to allow the rider easy access to this data. It would also be important to state the vehicle cannot be driven in rain or snow since the chassis is not weatherproof. The vehicle would also be tested in a variety of temperatures. Data would be

collected to inform the customer of possible premature component malfunction at varying operating temperatures, and this would be displayed in the user manual. One last consideration is to determine how great of a hill or incline the Two Wheel Deal can affectively travel over. This would be included in the user manual and possibly on a warning label on the vehicle.

This brings up a second ethical concern. This concern includes where warning labels should be placed as well as what dangers need warning labels. One warning label would be placed on the bottom of the machine near the batteries. It would warn the user of the danger that could occur if the batteries are shorted together. It would provide a picture of an electrical hazard as well as a reference to a page in the user manual that the rider could find more information on the danger. There would also be a warning label placed near the charging circuit for the batteries. It would display the potential fire hazard if the batteries were charged incorrectly. It would also have a reference to the user manual for more details on the danger. Two other warning labels would be placed on the outside edge of the frame above the small fans used to keep the motor controller PCBs cool. It would depict a moving fan warning to prevent anyone from accidentally sticking their fingers near the fans if they reach under the vehicle. A warning label would be placed on the floor of the vehicle depicting only one rider at a time on the Two Wheel Deal as well as a weight limit. This is important since the motor shafts have a maximum weight limit that can be applied, and since the warning label is on the floor of the vehicle a rider would see it each time he/she gets on it. There would also be a warning label placed on the LCD box that warned the user of the maximum angle the vehicle should be tilted to as well as the greatest incline the vehicle can safely maneuver. By placing this near the display the rider can always check the current tilt angle shown on the LCD with the maximum. Information on the tilt angle as well as incline would be included in the user manual, which is another ethical concern.

User documentation is vital because it gives the engineers and the developing company a direct way to provide the user with crucial information to protect his/her safety. The most important part of the documentation would be the user manual. This would include specific details on how to drive the vehicle, how to care for the vehicle, and how to troubleshoot problems that may arise. The manual would include information on the various environments described earlier, how the vehicle will react differently, and instructions on special actions that need to be taken during those environments. The manual would also include a list of warnings that the rider needs to be aware of when on or near the machine. It would explain in more detail

some of the warning labels of the vehicle. Finally the user manual would include contact information to the Two Wheel Deal retailers as well as maintenance and disposal/recycling centers, which will be explained later.

Also included with the user manual would be a training DVD to help new users or old users wishing to refresh skills. This would provide an opportunity to see the Two Wheel Deal in action and help users become acclimated with how the vehicle can be operated. This would be the same DVD that users would watch when they buy their first Two Wheel Deal from the dealer. Once the users have watched the video they would then be able to try operating a practice Two Wheel Deal at the dealer with the aide of a trained professional. By going through this quick and easy onsite training, the company and engineers can know for sure that the new users won't injure themselves when attempting to ride the Two Wheel Deal for the first time at home.

One final ethical concern and additional way to prevent user injury is the utilization of safety mechanisms. One safety mechanism that would be added to the Two Wheel Deal is a tone that would sound when the rider was getting close to the limit the vehicle can be tilted. This would help ensure the rider doesn't tip the vehicle over. In addition to the warning tone a function would be added in software that caused the wheels to turn close to the maximum speed for a short time if the limit is reached. This would cause the vertical stick to tilt back due to the increased speed of the wheels and thus causing the tilt angle to decrease. The program functionality would continue as normal once a certain angle was reached. Another safety measure that would be added would be an increased number of accelerometers and gyroscopes. These extra sensors would act as redundant circuitry that would verify the readings from the accelerometer and gyroscope. If the sensors were not then the redundant circuitry would be utilized, and a warning would be displayed on the LCD screen to let the rider know there is a sensor issue. A watchdog timer would also be implemented to ensure the microcontroller continues to function correctly. Finally a function would be written to allow the vehicle to come to a slow but controlled stop if the battery voltage or any PCB voltage dropped to an unsafe level rather than simply shutting down completely. Those are some of the ethical challenges that would be faced if the Two Wheel Deal would be released to the public.

### **3.0 Environmental Impact Analysis**

In addition to the ethical concerns addressed earlier, there are environmental concerns that need to be considered. These will be divided into three stages that occur throughout the

product lifecycle. The first stage is the manufacturing stage. The greatest cause of environmental pollution during the manufacturing stage is the creation of the PCB due to the large amount of chemicals and natural resources that are needed. Typical pollution includes industrial wastewater from PCB rinsing; alkaline/acids from cleaning and etching the PCB; and potentially hazardous metals such as lead, chromium, and palladium from contacts and traces [3]. All of these potential hazards have the opportunity to be reduced using certain processes available to all PCB manufacturers. Examples include material substitutions such as using alkaline solutions rather than solvents for degreasing operations, adding multiple tanks in the rinse system to improve efficiency, and minimizing bath solution concentrations to the lower end of their operating range [4]. These concerns would be addressed by choosing a PCB manufacturer who follows these procedures and is RoHS compliant, which is a certification restricting levels of certain hazardous materials [5]. That would ensure that environmental hazards created from the PCB would be at its lowest. One other minor concern is the choice of hardware components. Many various components include lead and other metals that can pose as potentially dangerous to the environment. Ensuring that the hardware components chosen are RoHS compliant as well would help decrease environmental impact.

The next stage is the normal use stage of the Two Wheel Deal's life cycle. Thanks to the emission-free, electric drive there are very few environmental concerns during this period. The only main concern is the use of sealed, lead-acid batteries. These batteries contain sulfuric acid and heavy metals, both of which are environmental hazards [6]. Caution must be taken when handling these batteries to ensure the plastic casing is not punctured or broken to prevent leaks from occurring since the sulfuric acid can burn through almost anything. Directions on how to handle the batteries would be included in the user manual and described in the training session provided when purchasing a Two Wheel Deal. Another caution must be taken while recharging the batteries. If caution is not taken and the battery is overcharged there is a chance it can explode which would spray sulfuric acid everywhere. There would be a warning placed on the battery as well as a reference to the user manual for helpful directions for recharging the batteries. There would also be recommendations on various chargers that work the best.

The last stage of the Two Wheel Deal life cycle is the disposal/recycling stage. This is the most important stage since many parts of the vehicle can be reused or need to be disposed of properly. Proper disposal of the vehicle components is recommended because many of the metal

pieces in the frame can be recycled. The motors can be refurbished and the batteries can be recycled to help create new batteries from recycled materials. Finally the PCB contains lead and other dangerous metals. These metals can also be found in the hardware components and LCD.

To facilitate environmentally safe and practical disposal and recycling for the Two Wheel Deal, a combination of core charges would be added to the initial cost of the vehicle. Core charges would be created for major components such as the motors and batteries which can easily be recycled or reused if they no longer work or simply need repaired. The last core charge would be for the entire rest of the vehicle. The way the process would work is that if a customer needed a new battery or motor, he/she would take the item to a Two Wheel Deal Recycling Center and receive the core charge for bringing the item back, after verifying the customer purchased that item, to be disposed of properly. He/she could then purchase a new item if necessary. The Recycling Center would then send the item to be reworked or recycled in places such as a battery recycling center or a company that refurbishes used motors. Directions, details, and contact information for this process would be specified in the user manual.

The core charge for the rest of the vehicle would work in a similar fashion. If the vehicle is no longer in operating condition or the customer decides he/she no longer wants it, then it can be returned to a Recycling Center. After verifying the customer purchased that vehicle, the core charge would be awarded depending on how much of the vehicle is returned. If there are items missing such as the PCB or the LCD, then a certain percentage of the core charge corresponding to that item would not be returned to the customer. The Recycling Center would then disassemble the vehicle to determine if items or components can be reused in new vehicles. Anything that could not be used would be sent to appropriate recycling centers. Directions, details, and necessary contact information on this process would be included in the user manual.

#### **4.0 Summary**

This is a summary of some of the ethical and environmental concerns that would come with making the Two Wheel Deal available to the public. The ethical concerns are centered mostly on the safety of the rider as well as preparing the rider and vehicle for a variety of environments and terrains. The environmental concerns are focused mainly on limiting pollution produced from creating new PCBs as well as ensuring easy and motivating processes to ensure safe disposal or recycling of hazardous materials contained in the Two Wheel Deal.

**List of References**

- [1] Engineering at University of Michigan, “Modeling an Inverted Pendulum”. [Online]. Available: <http://www.engin.umich.edu/group/ctm/examples/pend/invpen.html>. [Accessed: Apr. 6, 2008].
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- [3] American International Group, “Printed Wiring Board Manufacturing”. [Online]. Available: <http://www.aigenvironmental.com/environmental/public/envindustries/0,1340,63-11-333,00.html>. [Accessed: Apr. 7, 2008].
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- [6] U.S. Environmental Protection Agency, “Batteries”. [Online]. Available: <http://www.epa.gov/garbage/battery.htm>. [Accessed: Apr. 7, 2008].

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