AME 40463 – Senior Design

Individual Concept Memo

Design Specifications

1. The design must complete a payload transportation such that the rotation of the drive wheels are within 90-95% of the slip condition. This will prevent skid marks and ensure reduced transport time through the elimination of kinetic friction in the drive wheels.

2. The final design must initiate pushing within 5 seconds of contact with the force plate to ensure minimum time.

3. The chassis must be made of metal to demonstrate a professional appearance.

4. The final design must implement a gearbox which is compatible with the motor, made by the same company that made the motor, that is a Banebots P61 series.

5. The final design must have a kill switch and tether switch to ensure safety; the tether switch should have a functional radius of 30 ft.

6. The final design must autonomously move a payload of at least 25 lbs a distance of 20 ft and must stop before reaching 25 ft.

7. The final design must have a maximum weight of 17 lbs.

8. Lead acid batteries must be sealed to ensure safety. The final design must include a 30 A fuse to ensure safety. The final design must use 2 in diameter shore 60 wheels. The rubber bumper must maintain contact with the force plate without separation for the duration of the movement to eliminate any impact or collision. The final design should not impact against the force plate with a force greater than two times the continuous pushing force [2]. The final design must contact the force plate at a height of 3 inches (tolerance of $\pm$ 0.2 inches). Vehicle control should be accomplished via a feedback system which actively measures and adjusts

the vehicles speed and acceleration. The final design and its fabrication cannot exceed $500, leaving a $50 contingency budget.

9. The robot must complete pushing task, that is the time between starting pushing and reaching 20 ft, within 5.19 s. [1] shows that an Amazon robot can travel at $1.3\frac{m}{s} \approx 4.27\frac{ft}{s}$. Assume it takes 1 second for the robot to reach top speed. Using the physics equations of motion,

$$x = x_0 + v_0 t + \frac{1}{2}at^2 \tag{1}$$

$$\begin{aligned} x &= 0ft + 0\frac{ft}{s} \cdot 1s + 124.27\frac{ft}{s^2} \cdot (1s)^2 \\ &= 2.13ft \text{ to reach top speed} \end{aligned}$$

After reaching top speed, assume the robot maintains this constant speed until it reaches a total distance of 20 ft. Using equation 1,

$$\begin{aligned} 20ft &= 2.13ft + (4.27\frac{ft}{s}) \cdot t + 12(0\frac{ft}{s^2}) \cdot t^2 \\ t &= 4.19s \text{ to travel from 2.13 ft to 20 ft} \end{aligned}$$

Therefore, it is estimated that the Amazon robot could complete the task in 5.19 s, assuming that the time starts when the robot begins pushing and ends when the robot reaches 20 ft. To be competitive with the Amazon robot, the final design should complete the task in the same amount of time.

10. The vehicle should not deviate more than 3 from a straight path of travel ($\pm$ 0.698').

11. All fabrication must be completed with the tools provided in the Notre Dame Student Fabrication Lab.

12. The vehicle must fit within a 15" x 20" x 14" storage locker.

13. The vehicle must be capable of producing a pushing force of at least 25 pounds even if it is unable to move the payload.
14. If the motor stalls for 5 seconds, it will shut off to prevent it from being permanently ruined.
15. All wheels must maintain contact with the ground to maintain balance.
16. The pushing force must be wirelessly recorded in a way that it can be plotted as a function of time.
17. The control system must be capable of adjusting motor speed based on payload weight.
18. The final design must be complete by Tuesday, December 3, 2019.

References

[1] Guizzo, Eric. "Three Engineers, Hundreds of Robots, One Warehouse." *IEEE Spectrum*, vol. 45, no. 7, 2 July 2008, pp. 26–34., doi:10.1109/mspec.2008.4547508.

[2] Akin, J.E. "Impact Load Factors for Static Analysis." *Rice University*. https://www.clear.rice.edu/mech403/HelpFiles/ImpactLoadFactors.pdf.