

# ME14 Transmission Contest

SPRING 2025

---

## CONTEST DETAILS

### Safety

A transmission that is judged to be a potential safety risk to any participant or spectator will be disqualified. It is mandatory that safety glasses be worn always while fabricating and testing. It is, of course, also mandatory that safety glasses be worn always while in the M.E. Shop.

### Energy Sources

The power used by the transmission to spin the load wheel is limited to the power supplied by the electric motor. This must be true on an instant-by-instant basis, which means that no appreciable energy from the motor can be stored in the transmission.

### Transmission Project Materials

Your transmission will be constructed using from materials supplied by the M.E. Shop in addition to your single order(s) to McMaster-Carr and/or SDP/SI for this project.

The ME Shop will provide each team with the following items:

- 6" x 24" x ~1/2" thick acrylic sheet (or other dimensions depending upon availability at the time our order is placed)
- 1.5-in diameter x 6" length aluminum round stock
- 5/16" diameter x 24" length aluminum shaft (optional you may purchase your own)
- 5/16" diameter x 24" length steel keyed shaft (optional you may purchase your own)
- 3/8" diameter x 24" steel keyed shaft (optional you may purchase your own) Two 5/16" bore Flexible shaft coupling hubs, for attaching to the transmission setup (<http://www.mcmaster.com/#6408k11>)

Additionally, the following items will be available for all teams to use:

- 10-32 socket head cap screws, various lengths
  - 1/4" and 5/16" retaining rings
  - Additional supplies, subject to John's approval
- 
- The shop has tools for making retaining ring grooves and a broach set for cutting keyways.
  - Replacement supplies and materials are available on a limited basis. When in doubt, check with the shop.
  - Glues and epoxies may be used only for bonding.
  - These materials may be mechanically modified in any way (disassembled, cut, machined, ground, etc.).
  - The project materials may not be altered chemically (except locally by glues for bonding).
  - Welding is not permitted.
  - Light machine oil, mineral oil, or vegetable oil can be used SPARINGLY to lubricate. Do not contaminate the evaluation apparatus. For many traction materials, including belts and pulleys, once they are contaminated with oil it is nearly impossible to effectively clean them.
  - It is permissible to build tools, jigs, and fixtures to help fabricate your transmission, and also to help prepare it for evaluation. For example, you might want to build a template or other device to help ensure that your transmission is set up "perfectly" before each evaluation. This may help provide consistent performance.

- You are not allowed to use the laser cutter, water jet, 3D printer, or CNC machine for any components in your transmission contest.

## Transmission Specifications

### Size:

When each evaluation begins, your transmission must fit into a 7" tall x 6" wide x 8" long (inside dimensions) Plexiglas box with the width dimension being the dimension from the input shaft to the output shaft. This rule requires your entire transmission to fit inside the box at  $t=0$ , when electrical power is applied, at the start of the evaluation. A Plexiglas testing box is available in the M.E. Shop to check the size of your transmission. You must mount one of the provided shaft coupling hubs to both your input and output shaft. You should use the transmission setup in the ME Shop to determine the lengths of your input and output shafts, and as well as the required positions of the shaft coupling hubs.



**Figure 1** Figure 3 Plexiglas box with the width dimension being the dimension from the input shaft to the output shaft.

**Transmission Ratio:** Teams should design their mechanical transmission around a targeted gear ratio in the range  $5.0 < N < 7.0$ .

**Mass:** There is no limit on the transmission's mass; however, you must be able to install/de-install it within the allocated time.

### Installation:

Four threaded mounting holes are provided to simplify the installation of your transmission. It is recommended that you use at least two of these to fasten your transmission to the mounting platform shown in the figure below. Note that the transmission may be placed anywhere within the 6 x 12-inch outline on the mounting platform at the start. Both the motor and wheel have flexible 1/4-inch shaft couplings to connect for misalignment, as well as flexible spider shaft couplings that connect to your transmission. Examine your transmission and be sure to evaluate it on the testing apparatus before the contest day (note that no sensor readings will be made available until the day of the contest).

# Transmission Mounting Plate

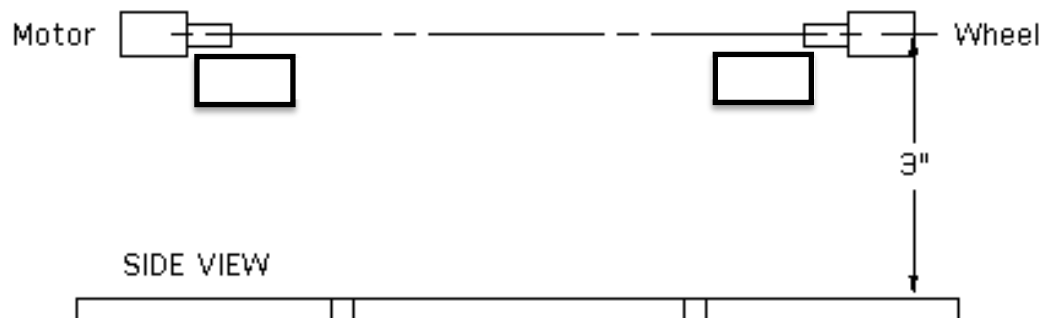
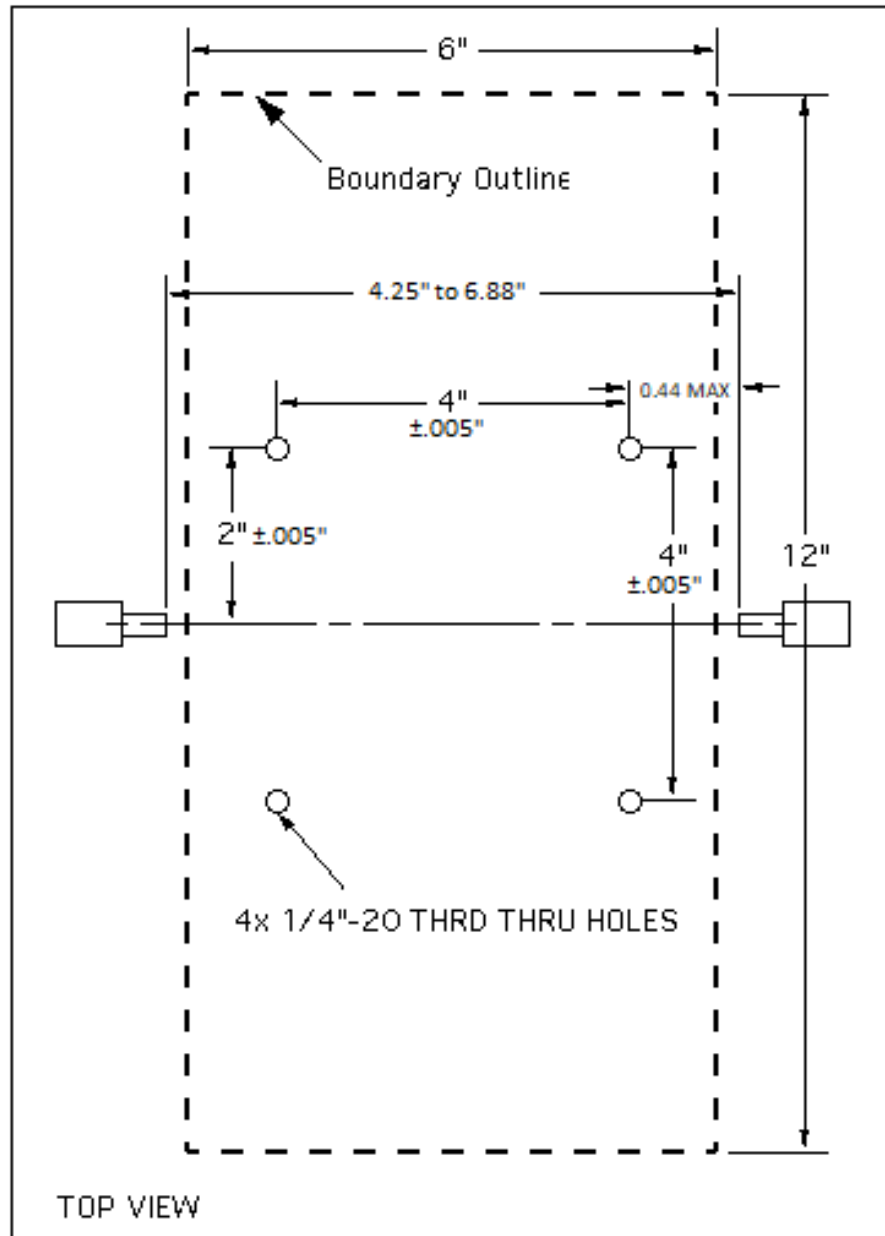


Figure 4 Top view of transmission apparatus mounting plate

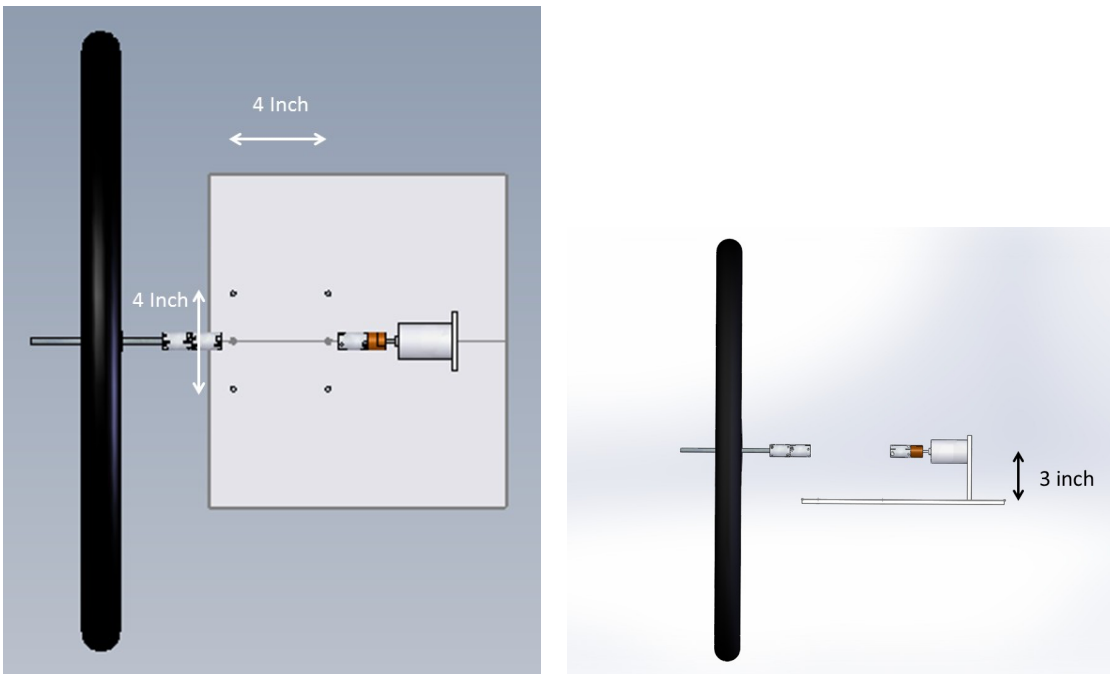
## Evaluation Apparatus

- Flexible couplings with 1/4-inch ID split clamps are provided on both the motor and wheel shafts. These flexible couplings can accommodate 0.020-inch of radial misalignment, and 5° of angular misalignment.
- The motor and wheel shafts will additionally have spider shaft couplings, which allow for an easy connection to your transmission.
- **The rotational inertia of the load wheel is approximately:  $I = 0.167 \text{ [kg-m}^2\text{]}$**
- **The combined rotational inertia of the motor and gears is approximated by:  $I = 0.0009 \text{ kg-m}^2$**
- The motor performance at its normal operating voltage of 12V is characterized by the following (approximate) specifications:

**Stall Torque ( $T_s$ ) = 0.133 N-m**

**No-Load Speed ( $\omega_0$ ) = 5500 rpm**

- Intentional damage to the evaluation apparatus will result in disqualification.
- The evaluation apparatus will be available in the ME Shop for transmission testing for the duration of the project.



**Figure 2 Critical dimensions of the transmission testing apparatus**

- The load wheel has the following experimentally measured performance properties: (note that these are approximate, limited by our measuring capabilities).
- **Wheel Model:** A curve fit to the measured drag torques has the following form ( $w$  is the wheel speed in radians/second):

$$\text{Drag Torque [N-m]} = 0 w^3 + 3.95 \times 10^{-5} w^2 + 9.50 \times 10^{-4} w$$

- **NOTE: These parameters may be subject to change. Please check the web site for updates.**

## Time

The timing of the evaluation procedure is:

- 90 seconds to set-up your transmission, starting from when your group is called to start.
- 300 seconds maximum duration of each evaluation starting with the application of power. That is, if your device does not reach its top speed by 250 seconds, then we will evaluate your performance based on the data obtained at the end of this period. No action of the transmission is permitted prior to the application of electrical power to the motor.
- 90 seconds to remove your transmission after the evaluation.

## Grading

Remember winning isn't everything. Having the transmission with the highest "score" is not the goal of this class. The primary goal is to learn something about engineering design and to apply the engineering concepts that you have learned in this and previous courses to an actual design problem. Remember that your term grade will be only slightly influenced by your transmission's "score."

So that we can better understand your design solving process, you will be expected to document your work in a design notebook and turn it in with your design debrief.

The transmission contest is worth 100 points. Grading will be based as follows:

- **Contest Score (30 points)**  
The team with the top score will receive a full 20 points. Other teams will receive the contest score portion of their grade based upon the following formula

$$\text{contest score} = \frac{\text{your team's score} \times 30}{\text{top team score}}$$

- **Device (20 points)**  
You will be graded on the implementation of your design and the quality of your transmission. Factors include smoothness of operation, machining quality, and design robustness. This is independent of your score in the competition. Your entire group will receive the same score.
- **Preliminary & Critical Design Reviews (20 points)**  
You will be graded on the design review presentations uploaded to the Canvas assignment portal. Your entire group will receive the same score. Be sure to include all of the items described below. Your entire group will receive the same score.
- **Design Brief (10 points)**  
You will be graded on the your design brief submitted immediately after the competition. Your entire group will receive the same score.
- **Individual Contribution (10 points)**  
You will be given an individual score for your contribution to your team's project based on anonymous peer reviews submitted by your teammates about your participation and interactions with them during the project's design, build, and test phases.
- **Design Notebook (10 points)**  
Your notebook will be graded on how well it adheres to the general guidelines and best practices outlined in the course lecture notes. This is an individual score.

Your final grade for the project will be computed as follows:  $0.6 \times \text{Team Grades} + 0.4 \times \text{Individual grades}$

## Project Testing

The transmission apparatus will be available (in the shop) for testing approximately 1 week prior to the contest. Angular speed and torque measurement diagnostics will be disabled but teams will still be able to test fit their transmission and run it. Be sure to keep a record of your testing activities in your design notebooks.

**NOTE:** These rules are subject to change. As the rules evolve, any updated versions will be posted on the course web page

## Appendix: Motor Specifications for DC Motor

**Stall Torque:** 1360.3 g-cm (0.133 Nm)

**No load speed:** 5050 +/- 650 rpm (nominal value stated at 5500 rpm)

### Mabuchi DC Motor RS-555PH-3255

Originally designed to be installed in portable drills and printers. This model features improved design to reduce external noise levels. Has "wrap around" magnetic shield. High torque 380.3 gm-cm with a stall-torque figure of 1360 gm-cm. An excellent find for the small or medium sized OEM who requires modest quantities of this quality product but cannot satisfy the manufacturer's demand for large quantity purchases. Hundreds of application in Robotics, the RC field etc. (shaft is 1/4 flat - stainless steel 1/8" dia). No load speed is 5500RPM - excellent for "gearing down" to provide ultra high torque for larger projects. 1-7/16" dia x 2-5/8" long. Flatted shaft is 1/2" long. 3/16" push on terminals. This unit features 5 pole construction for higher torque and power efficiency, anisotropic magnets, and coil specs of 55 turns of 32mm wire

