

UNIVERSITY OF NOTRE DAME
DEPARTMENT OF AEROSPACE AND MECHANICAL ENGINEERING

**Engineering Design Requirements for Mechatronic Football Players and
Performance Evaluation Tests**

Scoring System:

The scoring system for the performance evaluation testing will quantify each player’s compliance with the Engineering Design Requirements based upon its designated position. Each evaluation event is scored on a scale ranging from 10 (if the player meets the design requirement) to a 0 (if the player completely fails to meet the design requirement). A composite test score for each player will be computed by a weighted-multiplier system to determine each player’s total score out of a possible 100 points. The multiplier scoring system is shown in Table 1, and the weights are based on the relative importance of the tests to each player’s position.

Players are classified based upon their primary function/s. The Team will be required to declare the player class prior to the evaluation tests. To receive scores for any of its players, the Team must declare at least one player a QB or QB/P, at least one player a QB/P or RB/P, at least one player a Center, and at least one player a Kicker.

1. QB – a player that is capable of taking the ball from the center and executing a hand-off.
2. QB/P – a player that is capable of taking the ball from the center, executing a hand-off and throwing a pass.
3. RB – a player capable of accepting the ball from a QB or QB/P and holding the ball.
4. RB/P – a player capable of accepting the ball from a QB or QB/P, holding the ball, and throwing a pass.
5. Line – a basic player
6. Center – a player capable of holding the ball and interacting with the QB or QB/P to initiate a play.
7. Kicker – a player or modified player capable of kicking the ball.

Table 1. Multipliers to calculate the final score for players at each position

EVENT	QB	QB/P	RB	RB/P	LINE	CENTER	KICKER
Speed	2.5	1.5	2.5	2.0	3.0	2.0	-
Control at speed	3.5	1.5	3.5	2.0	3.0	2.0	-
Positioning	-	-	-	-	3.0	2.0	1.0
Maintenance	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Throwing Precision	-	3.0	-	2.0	-	-	-
Handoff	3.0	3.0	3.0	3.0	-	3.0	-
Kicker							8.0
TOTAL	10.0	10.0	10.0	10.0	10.0	10.0	10.0

Maintenance Test:

Design Requirement: Team must be able to remove and replace the main power source battery/batteries and reassemble the player in less than 5 minutes.

Test Method: Each player will participate in the maintenance test. A maximum of two people may work on one player. On the official’s mark, the team will begin the replacement. They must successfully remove the old battery/batteries and replace it with a new battery/batteries. The official will stop the clock once the player is assembled into its *original* configuration.

Scoring: The score for the test will be based on the total time it takes to complete the test. If the team completes the test in less than 5 minutes it will be awarded a score of 10. If it does not successfully complete the test in less than 5 minutes, its score will be based on the following calculation:

$$\text{score} = \frac{5 \text{ minutes}}{\text{time to complete test}} \cdot 10$$

Speed Test:

Design Requirement: An average speed of at least 10 ft/s over a distance of 50 feet.

Test Method: The test course consists of a start and a finish line separated by a distance of 50 feet. Each player can start any distance behind the starting line so that they can reach their top speed before reaching the starting line. There will be three timing officials for the event, and they will begin timing once the player's front end crosses the starting line, as signaled by a fourth official positioned on the starting line. The timing officials will stop timing once the front end crosses the finishes line. These three times will be averaged for an official time for each player. A diagram is shown below in Figure 1.

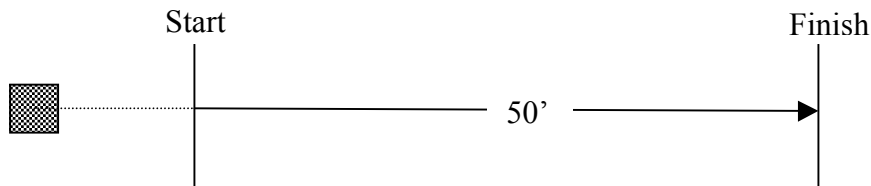


Figure 1. Diagram of the speed test

Scoring: The score for the test will be based on the average time it takes for the player to travel from the starting line to the finish line. Any time of 5 seconds or less will receive a 10 for the test. If a player does not complete the test in 5 seconds or less, its score will be calculated as

$$\begin{aligned} \text{score} &= 20 - 2 t \text{ (sec)} \text{ if } t < 10 \text{ sec.} \\ &= 0 \text{ if } t \geq 10 \text{ sec} \end{aligned}$$

Controllability Test:

Design Requirement: The ability to travel 50 feet in less than 10 seconds with a maximum deviation from a straight line of less than ± 2.5 feet.

Test Method: The test course will consist of two 50-foot pieces of tape placed parallel to each other at a width of 5 feet. The goal is to travel to the finish line 50 feet away without having the center of the player cross either of the boundary lines. The player will be placed at the starting line and on the official's mark will begin the test. The controller must remain behind the starting line during the test. One official will be in charge of timing the event, and two officials will be in charge of determining if the player's center crosses either of the tape boundary lines. A diagram is shown below in Figure 2.

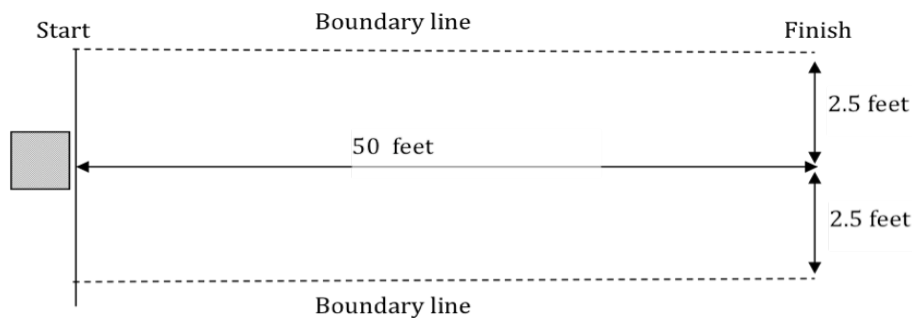


Figure 2. Diagram of the controllability test

Scoring: The score for the test will be based on the distance successfully traveled by the player within the allotted time. Each player will have 10 seconds to complete the drill. If a player reaches the finish line successfully in less

than 10 seconds, it will receive a score of 10. If the player does not reach the finish line in 10 seconds, its score will be based on its position at the end of the allotted time. If a player's center crosses one of the tape boundaries, its score will be based on its position at that point. If the player does not successfully complete the drill, its score will be calculated as

$$\text{score} = \frac{\text{distance traveled in 10 seconds or location where boundary is crossed.}}{5 \text{ feet}}$$

Positioning Test:

Design Requirement: A player must be able to move and reorient from a stationary position to a new prescribed location within 10 seconds and within a final position tolerance of ± 4.0 inches.

Test Method: Each player may be manually positioned within Square A, facing in the direction shown in Figure 3. When the controller signals he/she is ready to begin, the timing starts. The timing ends when the controller signals that he/she have positioned the player to his/her satisfaction within the boundary designated by Square B, nominally oriented in the position indicated. The timer determines if the player is completely within the boundary.

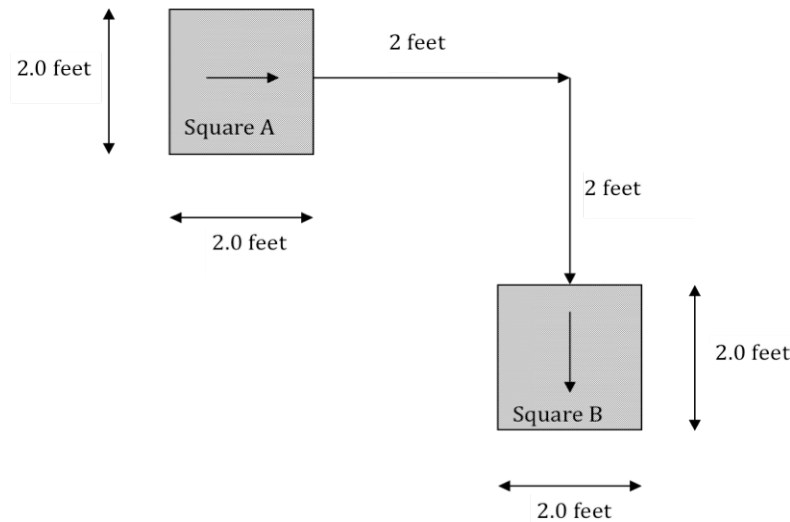


Figure 3. Diagram for Fine Position Tests

Scoring: The score for the test will be based on the average time it takes to complete the test over 3 test events. If the player is successfully positioned within Square B, the test time (in seconds) is recorded. If a player is not able to be positioned within Square B in 20 seconds, a test time of 20 is recorded. The player's score will be based on the following calculation with a maximum value of 10.

$$\text{score} = 20 - 3 \text{ event average}$$

Throwing Precision Test:

Design Requirement: The quarterback must be able to throw the ball between 5 and 15 feet (short-range) with a precision of at least 60% and throw the ball further than 15 feet (long-range) with a precision of at least 40%.

Test Method: The test will consist of two different precision tests. The quarterback will first throw a "targeting pass" within a 5 to 15 foot range. It will be given three chances to throw the targeting pass. The first pass that lands in that range is considered the target. An official will place the center of a hula-hoop with a 2-foot radius at the point where the targeting pass lands. If none of the three passes lands in that range, zero passes are scored for this range. Next the quarterback will have 5 attempts to throw the ball within the hula-hoop. A ball that lands inside or hits the hula-hoop, on the fly, is considered a success (completed), and any ball that lands outside the

hula-hoop is a failure. After completing the short-range trials, the targeting pass will be thrown farther than 15 feet, and the process will be repeated. A diagram of this test is shown in Figure 4.

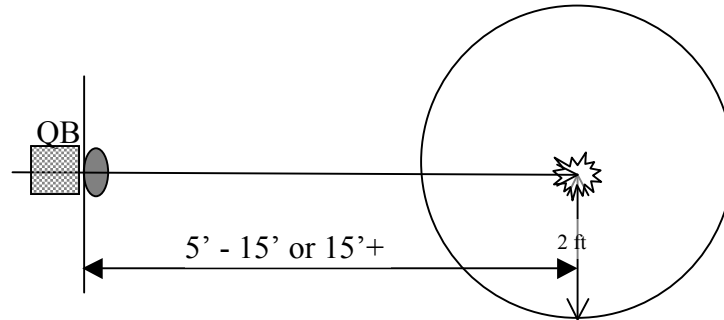


Figure 4. Diagram of the QB throwing precision test

Scoring: The score for the test will be based on the number of successful passes completed by the quarterback for the short- and long-range passes. If the quarterback successfully completes 60% or greater (3+/5) of the short-range passes and 40% or greater (2+/5) of the long-range passes, it will receive a score of 10 for the test. If the player does not successfully meet this requirement, its score will be determined according to Table 2.

Table 2. Scoring guide for the QB Throwing Precision test

		Long-Range					
		0	1	2	3	4	5
Short-Range	0	0	2	4	5	6	7
	1	1	3	5	6	7	8
	2	2	4	6	7	8	9
	3	3	5	10	10	10	10
	4	4	6	10	10	10	10
	5	6	8	10	10	10	10

Handoff Test:

Design Requirements: The handoff between the center, quarterback, and running back must be completed in less than 5 seconds with 100% reliability for 5 handoffs.

Test: The center, quarterback, and running back must be driven into formation for the test by their controllers. This formation will be chosen by the team but must be consistent throughout the test. On the official’s mark, the test will begin. The team will have up to 5 seconds to successfully transfer the ball to the running back. Time will stop once the running back secures the ball. The test will be conducted a total of five times. An attempt that results in a fumble or is not completed in less than 5 seconds is considered a failure. An attempt that transfers the ball to the running back in less than 5 seconds is considered a success. A diagram of this test is shown below in Figure 5.

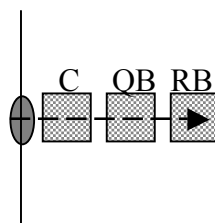


Figure 5. Diagram of the handoff test

Scoring: The score for the test will be based on the number of successful handoffs out of the 5 attempts. For each attempt, a successful handoff will result in a score of 2, and a fumble or a time of longer than 5 seconds will result in a score of zero. Thus, the scoring equation is as follows:

$$\text{score} = (\text{Number of successes}) \cdot 2$$

Kicker Test:

Design Requirement: A kicker must be able to kick the ball 32 ft in the air, and the ball must remain ± 8 ft of a designated target line-of-flight when the ball has traveled a distance of 32 ft in the air.

Test Method: The test is an evaluation of kicker distance and accuracy. The kicker may be manually positioned on the kicking test area shown in Figure 5. The ball will be manually positioned on the kicking tee for each test. The kicker will be given 8 opportunities to kick the ball. The orientation of the kicker may be manually changed between kick attempts. Two scoring judges will independently indicate the point where each kick lands and if it passed through the virtual goal posts. A split decision by the scoring judges will be ruled a successful kick.

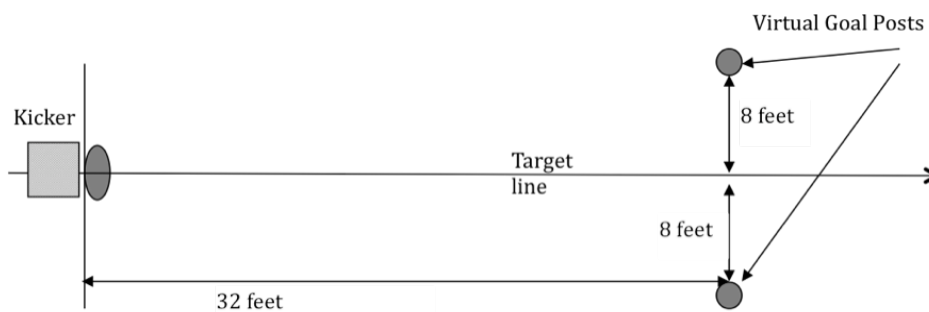


Figure 6. Diagram of the kicker test

Scoring: The score for the test will be based on the number of kicks that travel at least 32ft in the air AND pass between two imaginary uprights placed ± 8 ft perpendicular to designated target line-of-flight. The maximum test score is 10 (5 out of 8 kicks are successful). The scoring equation is

$$\text{score} = (\text{Number of successes}) \cdot 2$$

Player Weight Test:

Design Requirement: A player must weight less than 25 lb in order to participate in the performance test and receive a grade. (Complete Kicker players do not need to meet this requirement.)

Test Method: The player will be weighed using a calibrated scale prior to beginning the testing process by the course instructors. The decision of the instructors regarding the weight is final.

Scoring: If does not satisfy the design requirement it will receive a composite test score of 0.