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Superbowl Physics Worksheet 2: Static Friction

A controversy surrounded Tom Brady and the Patriots during the 2015-15 super bowl season. We will investigate a piece of this controversy using physics! This activity is designed to examine how static coefficient of friction between a football and the QB’s glove affects various outcomes such as velocity, contact time, acceleration, maximum vertical height, and the horizontal distance traveled. We will use newton’s laws, energy concepts and kinematics to determine this outcomes. Use g = 9.8 m/s^2. Carry out all mathematical operations to 3 decimal places.

The coefficient of static friction between the quarterback’s glove and a regulation football is mu1 =\_\_\_

The coefficient of static friction between the quarterback’s glove and a deflated football is mu2 =\_\_\_

The mass difference between the regulation and deflated footballs is negligible. Mass = \_\_\_ kg

The quarterback’s hand exerts \_\_\_\_ newtons of contact (or gripping, normal) force on the ball.

The quarterback’s hand is in contact with the ball for \_\_\_\_ meters during the throwing action.

The football is released by the quarterback at an angle of \_\_\_\_ degrees.

Solve each of the following using both mu1 and mu2.

1. Calculate net force which is equivalent to the frictional force of the quarterback’s hand on the ball (hint: Friction <= mu\*contact force).
2. Calculate the maximum possible work done on the ball by the quarterback’s hand. Assume the force applied is in the direction that the ball travels.

(hint: W = f\*d).

1. Solve for the acceleration of the football while in contact with the quarterback’s hand

(hint: Newton’s 2nd Law)

1. Assume that all work is converted into kinetic energy and that the ball begins at rest. Solve for the velocity of the football just as it leaves the quarterback’s hand.
2. Find the time in which the quarterback’s hand was in contact with the ball.
3. Find the Vx and Vy components of the initial velocity.

V1x: V2x:

V1y: V2y:

1. Use conservation of energy to solve for the maximum height reached by the football.
2. Use kinematics to verify your answer to the previous question.

(hint: use the 3rd Kinematic equation)

1. Solve for the ‘air time’ of the football. (hint: use the 2nd Kinematic Equation)
2. Solve for the horizontal distance traveled by the football. (hint: d=r\*t)
3. Find the percent horizontal distance improvement achieved by using the deflated football.
4. Find the increased horizontal distance traveled by the deflated football.
5. Find the percent vertical distance improvement achieved by using the deflated football.
6. Find the increased vertical distance reached by the deflated football.