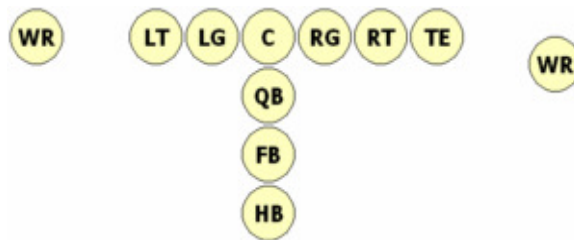


# Football wouldn't be Football without Physics

Football is the most physical sport. No other major sport places so much importance on players' size or positions. We all know that for each position (lineman, running back, linebacker, etc) there are different norms for height and weight; reason being, everyone on the field must be good at something different. These body-type differences are based on the rules of physics; specifically, mechanics, or the study of motion and its causes. Four elementary principles of football portray just how “physic”al the sport really is: running the ball, throwing/punting the ball, tackling the ball carrier, and blocking.

## Running and Stopping the Run

Running the football is one of the most important aspects of the game. The halfback is mostly responsible for this, and as such he must be one of the quickest and most agile players on the team. Let's examine a standard offensive formation, the I-formation:

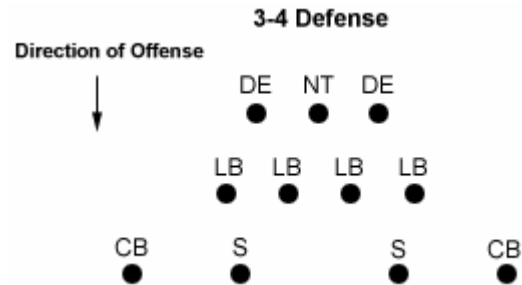


The halfback is farthest from the line of scrimmage; this enables him to reach a maximum speed before coming into contact with defensive players. As we know from physics, the higher the velocity, the more momentum one has.

$$p = mv$$

This large amount of momentum makes it difficult to tackle a halfback.

Linebackers are the other half of the running game. The halfback needs to be tackled, and a linebacker would be the perfect candidate.



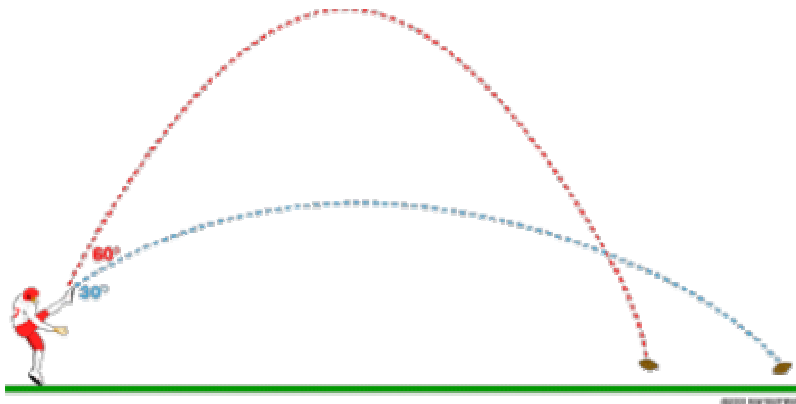
The linebackers are also lined up away from the line of scrimmage for the same reason as a halfback. However, they are not as far away; that is because the average linebacker is heavier than a halfback. Mass is the other half of the momentum equation. For a linebacker to be able to effectively tackle the runner, his momentum should be equal, or greater. If running back A has a mass of 98 kg, and a velocity of about 10 m/s, he has a momentum of 980 kg\*m/s. Now, linebackers are generally much slower than running backs; however, they are also quite a bit larger. For a linebacker with a mass of about 125 kg to stop the runner in his tracks, he will need to be moving 7.84 m/s; that's 2.16 m/s slower than the halfback. He may be moving slower, but his momentum (p) is the same, and when the two players meet both will stop.

## Throwing and Punting

Mechanics can also be applied to both throwing and punting the ball. When a quarterback throws the ball to a wide receiver, the ball is almost always thrown so that it is moving in a tight spiral. This spiral, compared to an end-over-end pass, produces much less wind resistance. This enables the ball to be delivered quicker and more accurately. The same concept applies to rifles. Longer barrels produce more rotation,

which is why firearms with longer barrels are more accurate.

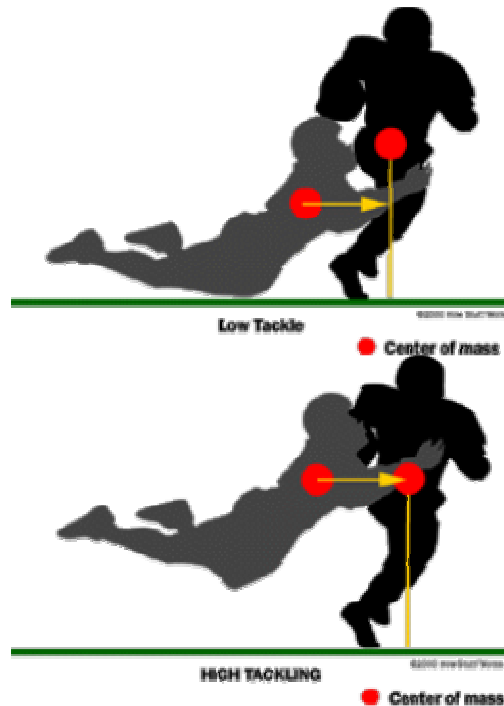
When punting the ball, the punter wants to kick the ball as far as he can; however, he also wants his punt to have adequate 'hang-time' which enables his teammates to make it to the punt returner and tackle him before he has a chance to build momentum. There are two basic, different types of punts: the end-over-end and the spiral. The end-over-end version is generally used when the punter wants a nice, unpredictable bounce. The real physics lies in the spiral punt; a spiraling kick will, as previously mentioned, will have much less air drag and will not slow down as fast and stay in the air longer. Two other factors that determine the distance and hang-time of a punt are the velocity of the ball and the angle of the kick.



The larger the velocity, the longer the hang-time and the farther the punt travels. Each punter strives to ensure that the ball leaves his ball with a maximum velocity. The angle of the kick is a much more subtle art. Kick the ball too steep, the ball won't travel as far, and the opposing team will start with better field position. Kick the ball too shallow, and the returner will have more time to build momentum before the coverage units can stop him. Punters have to mentally calculate the perfect angle at which to kick the ball, so that the returner has no time to return it before special teams tackles him.

# Tackling

Tackling is the most common occurrence in football. How and where a defensive player tackles the ball carrier depends on the effectiveness of the tackle.

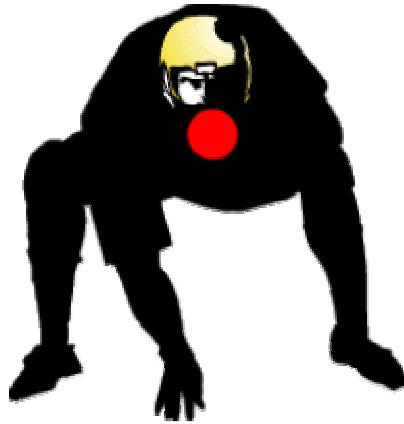


Every player, and every object, has a center of mass. For men, the center of mass is around the navel. When a force (F) is applied a certain distance from the center of mass, the object (in this case the player) will rotate. This force of rotation is called torque, which is the product of the distance from the center of mass and the force.

$$\text{torque} = Fd$$

Therefore, the greater the distance from the center of mass, the more torque you produce. Defensive players are taught to tackle the ball carrier low, away from the center of mass. This applies the force of the tackle farther away from the center of mass, which creates more torque, which enables the tackler to bring him down easier with the same amount of force.

The concept of torque also applies to blocking, the main job of offensive linemen. Offensive linemen are usually the biggest players on the field, which makes them even harder to push back. In addition to their large mass, linemen also crouch low when blocking.



Because their center of mass is closer to the ground, defensive pass-rushers are only able to make contact at or near the center of mass, making it difficult to rotate the linemen.

Running, tackling, blocking, and punting are four important aspects of the game of football, and they each involve physics. If coaches didn't preach these important techniques of football, the laws of physics would be on the opposing team's side. You can't win a game of football without physics.