The Dude sends his bowling ball down the lane toward the geometrically arranged pins at the far end. The ball slides without rolling at first on the highly polished and perfectly horizontal maple floor, but it eventually catches and thereafter rolls without sliding. Discuss what happens to the ball while it is on the floor (but before it hits the pins) in terms of horizontal forces, various energies, and momentum. First discuss the early period when the floor is essentially frictionless, then explain the later period when friction is important. Most critically, explain what happens during the transition between those two periods.

Transfer of energy occurs mediated by a tangential force

Since the floor is highly polished, we can assume that it is frictionless. Therefore, the kinetic energy will be conserved. Then the translational energy will be converted into rational energy. When the ball touches the surface, there are reaction forces at all point of contact, which includes the normal and frictional force. During the transition of those two periods, a reaction force at a point on a surface is resolved into two components , a normal force that is perpendicular to the surface and a tangential force. The momentum of the ball is the product of its mass and velocity.

Friction exerts a force and causes a torque

When the bowling ball is on the floor the horizontal force acting on the ball is kinetic friction. This force acts opposite to the motion of the bowling ball causing its velocity to decrease. When you swing the bowling ball and release it in order for it to make its way down the floor, the energy changes from potential energy to kinetic energy. When the ball. comes into contact with the pins, the following ball slows down and loses momentum, giving a certain amount of its momentum and passing it on to the pins.

A thorough explanation of the situation

When the ball is not rolling, there are only two forces acting upon it, the downward force of gravity and the upward normal force. These forces balance each other, so there is nothing to induce a rotation in the ball. This is only occurring because the surface is temporarily "frictionless". In addition, there is no force acting on the ball that will change is translational kinetic energy (the net force is zero). At the point when the ball catches, the missing force of friction arises. This is an unbalanced force acting against the direction of the balls motion, but more importantly, the force of friction is not being applied through the balls center of mass. Thus, it has a lever arm and can now be called a torque. This new torque that arises from friction is what causes the ball to rotate.

After the Dude's ball is rolling, and just before it hits the pins, describe the instantaneous velocity at the very highest point on the ball and estimate the speed there. Hint: estimate the data your need about a typical bowling ball's behavior from the video below but ignore the curve.

Rolling combines linear velocity of center of mass with tangential velocity around the center of mass

The top of the ball has both a linear velocity, and a tangential velocity as a result of its rotation. Let's say the ball has a linear velocity of 10 m/s. The linear velocity of the ball is a result of its rolling. Were it not rolling at this point it would just skid to a halt. The point at the top of the ball is covering the same linear distance in the same time, however its path is circular. In order for the ball's center of mass to be traveling at 10 m/s, the point at the top must be traveling twice as fast, so its velocity is 20 m/s

Problematic responses

....Therefore, at its highest point the velocity must be zero.

....As goes through this phase, a translational velocity goes one way as the angular velocity goes in the opposite direction. When this occurs it causes both translational and angular velocity to cancel each other out, resulting in the velocity at the top of the ball to be 0.

...At the top of the ball the translational velocity is going one direction as the angular velocity is going in the opposite direction, thus they will cancel each other out, causing the velocity at the top of the ball to be zero.

... At max height the point on the ball has an instantaneous linear velocity of zero because it is at the highest it will go.