Pump ED 101

Three Fictitious Forces & One Real Force

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There are two schools of thought when it comes to centrifugal force. The one I support views it as a false force but, the other side believes that it is real. They also believe that Elvis is alive and well, but don't let that influence your opinion. Centrifugal force (from the Latin meaning "center-fleeing") is an "apparent" force. In fact, its perceived "existence" depends upon our own frame of reference. It is one of three important forces in physics that we refer to as "fictitious" forces. The other two fictitious forces are the Coriolis force and Newton's (or Euler's) simple force due to acceleration. The major difference between a fictitious force and a real force is that real forces are based on the interactions of matter.

Force Due to Acceleration

When you step on the gas pedal and your car accelerates, you feel what you think is a force pushing you backwards in your seat. Once acceleration ends and speed is constant, that force seems to disappear. Of course there is no force pushing you backwards. It is the result of the forward force necessary to allow you to accelerate with the car. Newton's simple force due to acceleration is best described by Einstein's equivalence principle. It states that one cannot distinguish between a real and a fictitious force when in the same frame of reference. Therefore a space ship accelerating at 32 ft/sec/sec in outer space would create a force indistinguishable from that of gravity to an observer inside the ship. In fact, Einstein went so far as to suggest that even gravity could be a false force but he concluded that gravity (or any component of gravity) could be considered a false force at a single point only. This led him to suggest that the geometry of the earth and that of the universe cannot be explained in Euclidean terms. Gravity in four dimensional space, where the sum of the angles of a triangle do not necessarily equal 180 degrees, can be very different indeed!

Coriolis Force

The effect of the Coriolis force is an apparent deflection of the path of an object that moves within a rotating coordinate system. The object does not actually deviate from its path, but it appears to do so because of the motion of the coordinate system. In the case of our planet, it is a result of the earth's eastward rotation and its differing tangential velocities at various latitudes. If a long range gun is fired towards the North Pole from a point on the equator, its projectile will land to the east of its due north path. This occurs because the projectile is moving faster eastward at the equator than is its target further north. The opposite occurs when the direction is towards the equator. If an airplane leaves Anchorage Alaska and flies directly towards Miami Florida, it will be over Mexico when it crosses Miami's latitude. The Coriolis force also causes hurricanes to spin counterclockwise in the northern hemisphere and clockwise in the southern hemisphere. It does not, however, have any proven effect upon the vortex rotation of toilets in either hemisphere!

Centrifugal Force

The Dutch physicist and inventor of the pendulum clock, Christian Huygens, coined the term "centrifugal force" in 1659. Huygens believed that centrifugal force was a real force and his theory was supported by the German mathematician Gottfried Leibniz. Isaac Newton seemed to support the theory early on but eventually disagreed. He coined the term "centripetal force" in 1684 to describe what he thought was to only force that acted upon a body in circular motion. It was not until the mid 1700's that our current day understanding of centrifugal force as a fictitious force became entrenched. In 1746, Daniel Bernoulli said "the idea that centrifugal force is fictitious emerges unmistakably".

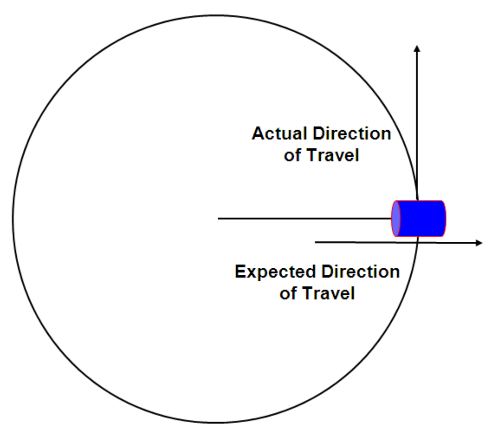

Figure 1 shows a can attached to a string and swinging in a counterclockwise direction. It is a common misconception that centrifugal force pulls outward on the can and if the string were to break that force would cause the can to travel outward (East). In fact, if the string breaks, the can will move in a straight line, tangent to its circular path. It does so simply because there is no centrifugal force acting on it! The only real force acting on the can, prior to the string breaking, (neglecting gravity) is the "centripetal" force (from the Latin meaning "center-seeking") supplied by the string. It is this centripetal force that holds the can in a circular path. Similarly, the earth's gravity provides the centripetal force that holds the moon in a nearly circular orbit. And, it is the friction between a car's tires and the road that provides the centripetal force necessary for it to round a curve.

Now, suppose for a moment, that someone is inside the whirling can. The can presses against his feet and provides the centripetal force that holds him in a circular path. From our frame of reference outside the can it is clear that this effect is due to inertia or the tendency of an object to follow a straight line path (as dictated by Newton's first law). If, however, we change our frame of reference from inertial (stationary) to that of the rotating can, we lose our original perspective and experience something quite different. We will "feel" a force that pulls our bodies towards the bottom of the can. Although it feels very real, it is not a force at all but the effect of inertia on our bodies. Nevertheless, to observers in a rotating system, centrifugal force seems to be a very real force.

So, what about that machine we refer to as a centrifugal pump? Is its operation based on centrifugal force? Well, if so, it must operate under false pretenses! Although mathematically complex, "centrifugal" pump operation is intuitively straight forward. The pump's impeller utilizes its vanes to channel or guide a fluid through an ever increasing radius while containing it within a rotating system. This process causes the liquid to accelerate continuously as it navigates the radius and reach some maximum velocity just as it reaches the impeller periphery. It then flows into the pump's volute where velocity is transformed into pressure.

What then should we call such a pump? Maybe we could call it a radial accelerator pump or a rotational inertia pump or just simply an impeller pump. Although there may be many descriptions that are more accurate, I'm afraid that we are stuck with centrifugal.

Joe Evans is responsible for customer and employee education at PumpTech Inc, a pump & packaged systems manufacturer & distributor with branches throughout the Pacific Northwest. He can be reached via his website www.PumpEd101.com. If there are topics that you would like to see discussed in future columns, drop him an email.