Final assignment

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1 Centripetal Force

Centripetal force is a popular type of force captured in real life. In general, when a centripetal force apply on an individual, its body is allowed to follow a curved path; although in most of the case the body moves in circular trajectory, the path isn't necessarily circular. The centripetal force on an object is a function of its body mass, tangential speed and the radius of the curvature trajectory; the magnitude of the force is F=(mv^2)$/r$
The direction of centripetal force is always orthogonal to the motion of the body i.e the direction of the velocity vector; it points toward the center of the curvature of the trajectory. In real life case scenarios, there are many types of force that can be served as centripetal force. In this paper, we only focus on these following types:
+Gravity
+Normal force
+Tension force
+Magnetic force
+Electrostatic force

2 When centripetal force is gravity

Gravity force is the force acting on every object (on the Earth) by the Earth, attracts them with their mass by the gravity acceleration. For most of the motion cases gravity force vector is agreed to point downward. In many case scenarios, an object body is forced to follow a curved motion due to gravity. One example of gravity as centripetal force is roller coaster. In roller coaster case, imagine that if there is no centripetal force, the cars on a typical roller coaster would fall out of their track due to huge acceleration, causing tragic accidents. In other words, centripetal force helps prevent the cars from taking apart from the track on curly paths. The gravity isn't the centripetal force in all case of the roller coaster; it only for when the cars are on the top of the lift hill case (Figure 1)
In this case, the only forces acting on the cars are the gravity force w pointing downward by the earth and the normal force n pointing upward. The combined

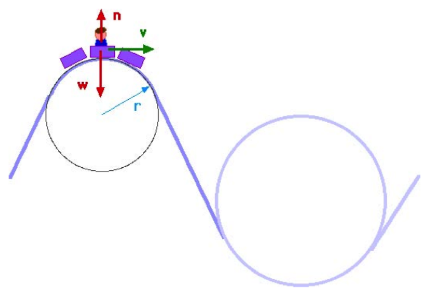

Figure 1: Example of centrifugal force – roller coaster cars on top of the lift hill

effect of these two forces together causes the net force Fnet become centripetal force as it points toward the center of curvature whose radius is r shown in Fig.1. Since the cars are on top of the hill, net force and gravity have the same direction and orientation.

$$F_net = w - n$$

$$(mv^2)/r = mg - n$$

So when does gravity become centripetal force? The answer is when gravity is equal to the net force, i.e the normal force between the cars and track is zero n=0. In that case:

$$(mv^2)/r = mg$$

$$v^2 = grorv = gr$$

Therefore, if the car is moving fast enough where its velocity is v=gr, the normal force becomes zero and gravity serves as centripetal force.

3 When centripetal force is Normal force

Normal force exerting on an object, by the standard definition, is the force that is perpendicular to the surface of contact with another stable subject. Although normal force is generally assumed as an opposite force with gravity, its vector doesn't necessarily point upward. The roller coaster case is again served as a perfect example for the normal force being centripetal force. For this part, the situation where the roller coaster cars are on the bottom of the hill is analyzed. This situation is fairly similar to the situation in part 1, where the cars are under the combined acting effect of two forces: downward gravity w by earth and upward normal force n by the track. Notice that the track serves as "stable

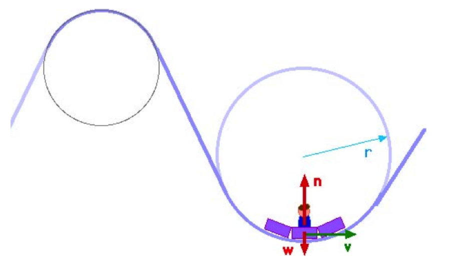

Figure 2: Figure 2 - Example of centrifugal force – roller coaster cars on bottom of the lift hill

subject" mentioned above. The net force caused by these two forces becomes centripetal force; however in this part it points upward to the center of curvature. Since the cars are on bottom of the hill, net force and normal force have the same direction and orientation.

$$F_net = n - w$$
$$(mv^2)/r = n - mg$$
$$n = (mv^2)/r + mg$$

The equation shows that in this case the normal force is greater than the gravity. But since the gravity force is always non-zero, it is impossible for the normal force to have same magnitude with the net force, although they have the same direction and orientation. Therefore, it's not genuinely correct to indicate that the normal force is the centripetal force; however it can be concluded that normal force is the main component of the centripetal force in this case, and it has the same direction and orientation with the centripetal force.

4 When centripetal is Tension force

Tension force is the force acting on an object that connects with an end of a string.The force is transmitted through the string and acts on the same line, has same magnitude but different direction with the force that the object acts on the string. Fig.3 illustrates the situation where tension force involved in the circular motion of an object. The object is tighted to the string and spun in horizontal plan; it is observed that the object moves in circular orbit. Fig.3 shows the vertical view of the motion. In general, the only force that causes the motion is the string tension; gravity is ignored since it acts perpendicular to the velocity vector and thus doesn't contribute to the motion.

$$Fnet = T$$
$$(mv^2)/r = T$$

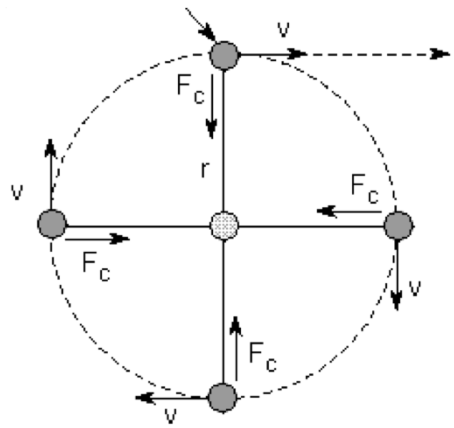

Figure 3: an object is tighted and spun in horizontal plane

5 When centripetal is Magnetic force

When an object locates or moves in a magnetic environment i.e. a magnetic field, it is affected by the magnetic force. For the purpose of this paper, I consider the case where a charged particle is moving in a magnetic field. In general, the magnetic force acting on the charged particle in this case is a function of its electric charge, its instantaneous velocity, and the magnetic field.

$$F = qvB$$

Fig.4 illustrates the particular case for this part. A charged particle is moving in the plane perpendicular to a magnetic field. Magnetic force is the only force exerted on the particle on this case. The direction of the force depends on the direction of the magnetic field and its velocity and is determined by the right-hand rule. As a result, the particle will follow a circular trajectory, and the magnetic force, which is the only force exerted on the particle, serves as the centripetal force.

$$Fnet = qvB$$

$$(mv^2)/R = qvB$$

Therefore,

$$R = mv/qB$$

In reality, people are able to observe the similar phenomenon which is the circular travelling motion of the electrons in magnetic field in the microscopic laboratories.

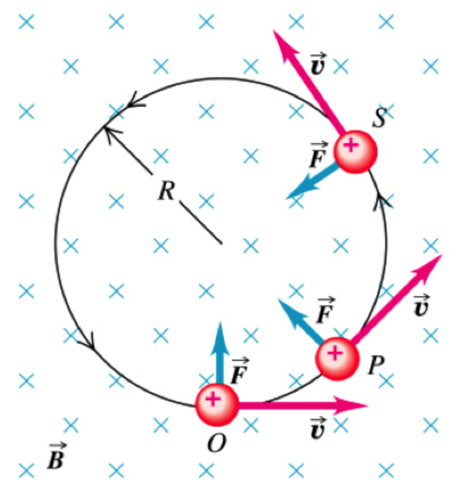

Figure 4: a charged particle moving in circular orbit caused by magnetic field

6 When centripetal is Electrostatic force

Electrostatic is the reacting force between two charged particles or objects. The force is repulsive if those two particles or objects have the same sign and is attractive if they have opposite signs. The electrostatic force is a function of the charge of the particles and the distance between the particles.

$$F = k(q_1 q_2)/r^2$$

The most basic case where the electrostatic force becomes centripetal force is the interaction between the electrons and the nucleus of a molecule (Fig.5). The electrostatic forces between the electron and the nucleus are the blue arrows. In general, the electrostatic force exerted on the electron by the nucleus causes the electron to travel around the nucleus following a circular trajectory.

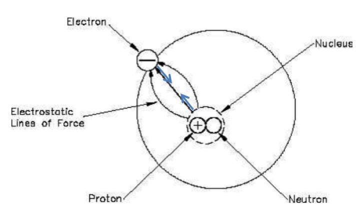

Figure 5: Electrostatic force causes the electron to travel around the nucleus of a molecule

The equation for this motion is:

$$Fnet = Feletrostatic$$

$$(mv^2)/r = k(q_1q_2)/r^2$$
$$v = (k(q_1q_2)/rm)$$

Where m is the mass of an electron, which is approximately 9.11 x 10-31kg.