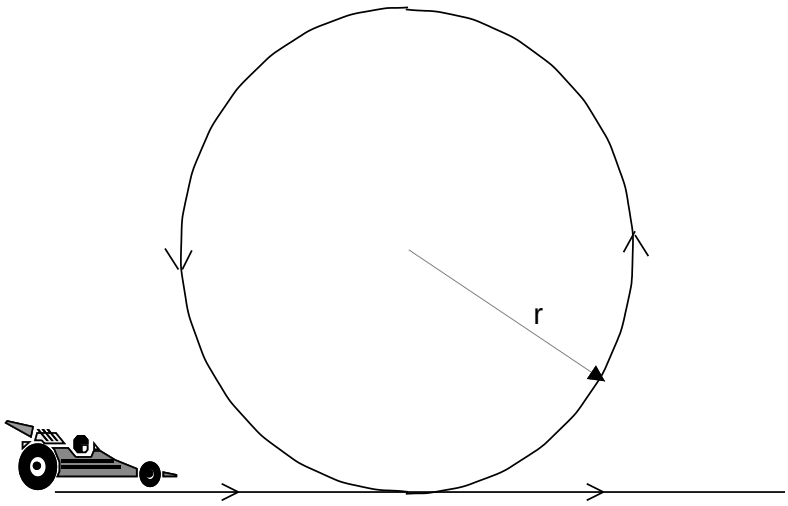
The Loop-De-Loop

A small experimental roller coaster car and single rider have a combined mass of 200kg. They are attempting to successfully go around a completely circular vertical loop with a constant radius of 25m. The speed that they go into the loop at is 72 km/h.

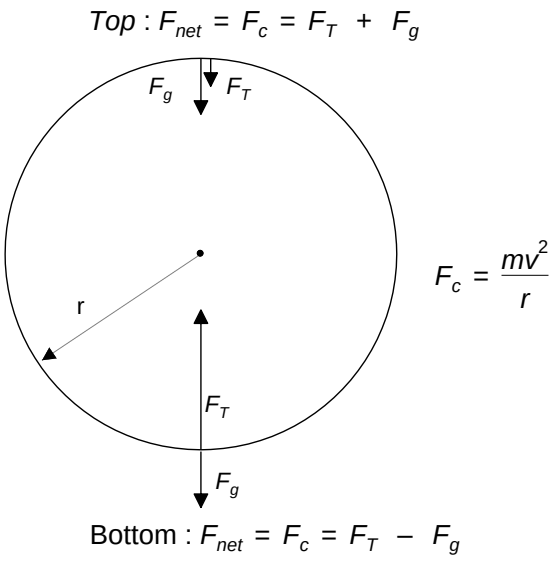


1. Calculate the normal force the track exerts on the car (we have called this tension in questions about a mass swinging on a string) at the top of the loop.
2. Calculate the normal force of the track on the car at the bottom of the loop.
3. How many g's does the rider experience at the bottom of the loop? Is this a realistic value for an amusement ride?
4. How many g's does the rider experience at the top of the loop?
5. What is the minimum speed the car could travel at to ensure it didn't fall out of the track at the top?

Loop-De-Loop Problems

Previous questions dealt with motion in a horizontal plane. When considering circular motion in a vertical plane, gravity is now contributing as a force into the centripetal force.

In the diagram to the right F_T can stand for tension force, normal force of a track on a car, or even the force of air on a plane flying in a vertical loop.



$$F_c = \frac{mv^2}{r}$$

1. A mass of 0.500 kg is being spun on a string in a vertical circle with a radius of 0.750m. The mass is rotating at a frequency of 0.900 c/s.
   a. Determine the force of gravity on the mass.
   b. Find the centripetal force needed to keep it spinning at a constant speed in the vertical circle.
   c. Calculate the tension in the string at the very top and the very bottom of the circle.
2. An object of mass 3.0 kg is whirled around in a vertical circle or radius 1.3m with a constant velocity of 6.0 m/s. Calculate the maximum and minimum tension in the string.
3. A plane is flying in a vertical loop of 1500m radius. At what speed is the plane flying at the top of the loop if the vertical force exerted by the air on the plane is zero at this point?
4. When you whirl a ball on a cord in a vertical circle, you find a critical speed at the top for which the tension in the cord is zero. This is because the force of gravity on the object itself supplies the necessary centripetal force. How slowly can you swing a 2.5 kg ball like this so that it will just follow a circle with radius 1.5m?
5. The pilot of an airplane, which has been diving at a speed of 540km/h, pulls out of the dive at a constant speed.
   a. What is the minimum radius of the plane's circular path in order that the acceleration of the pilot at the lowest point will not exceed 7g?
   b. What force is applied on an 80kg pilot by the plane seat at the lowest point of the pull out?
6. Snoopy is flying his vintage war plane in a "loop-de-loop" path chasing the Red Baron. His instruments tell him that the plane is level (i.e. at the bottom of the loop) and travelling at 180km/h. He is sitting on a set of bathroom scales and notes that they read four times the normal force of gravity on him. What is the radius of the loop?

Answers :

1a. F_g=4.9N, b. F_c= 12.0N c. top F_T=7.1N bottom F_T=16.9N 2. max F_T= 112N min F_T = 54N

3. V=121m/s 4. V=3.8m/s 5.a. r=383m b. F_n5490N [up] 6. r=85m