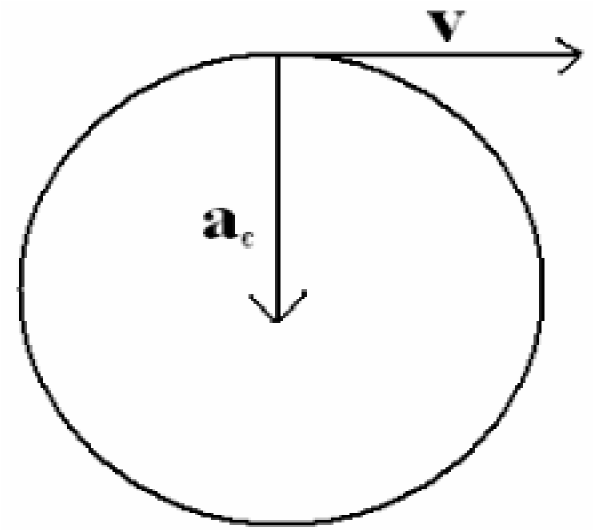
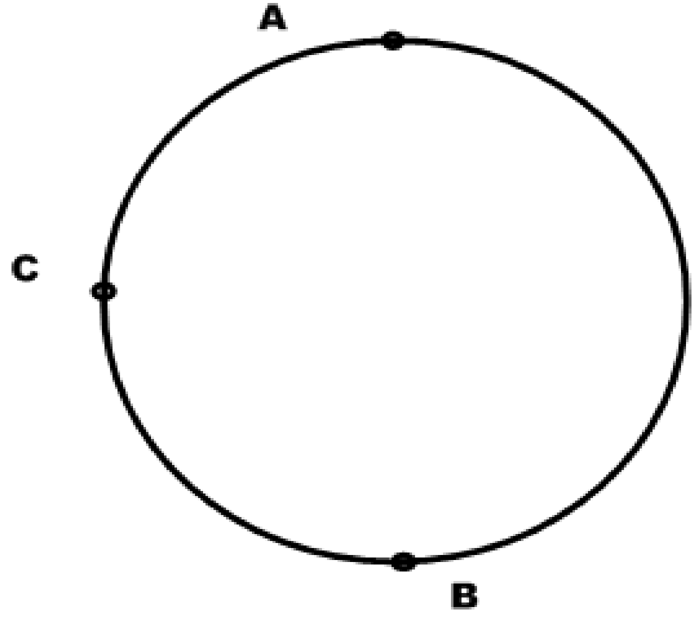
Vertical Circles



Swinging Vertically

- A mass m is twirled in a vertical circle of radius r. The mass is held at the length of a string with tension T.

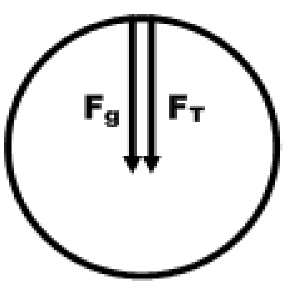
- Vertical Circle



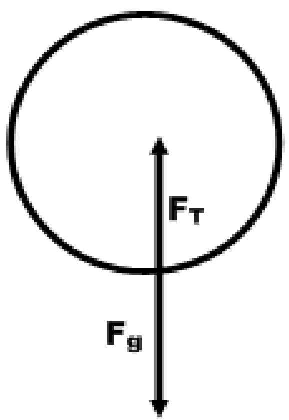
Free-body diagrams

- The free-body diagrams showing the forces acting on the mass are shown below for each point. Notice, there is no centripetal force indicated. It is not a separate force.

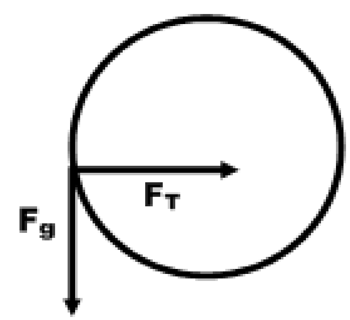
- Point A



Point B



Point C



Net Force

- The sum of the forces is the net force, which, in this case, is also the centripetal force.

- $F_{net} = F_g + F_T$

Point A- Top of Loop

- At point A: the tension and the weight act in the same direction. Their sum represents the centripetal force.

- An object is swung in a vertical circle with a radius of 0.75 m. What is the minimum speed of the object at the top of the loop for the object to remain in circular motion?

$$F_c = F_g + -F_T$$

Point B- Bottom of Loop

- At point B: the tension acts toward the center of the circle and the weight acts down. Their sum represents the centripetal force.

- A string requires a 135 N force in order to break. A 2.00 kg mass is tied to this string and whirled in a vertical circle with a radius of 1.00 m. What is the maximum speed that the mass can be swung without breaking the string?

$$F_c = F_g + F_T$$

Point C- on side of loop

- At point C: only the tension acts toward the center of the circle. The weight has no effect.

- A bucket of water with a mass of 10 kg is swung in a circle, attached to a rope that is 1.2 m in length. It takes 1.5 s to complete one loop. Calculate the tension in the rope when the bucket is parallel with the ground.

$$F_c = F_T$$

Horizontal Circles

- **The centripetal force is a result of only the force due to tension acting toward the center of the circle. The weight has no effect.**

- **If moving along a road, the tension can be replaced by the only force keeping the car from flying out of the circle, friction**

$$F_c = F_T$$

or

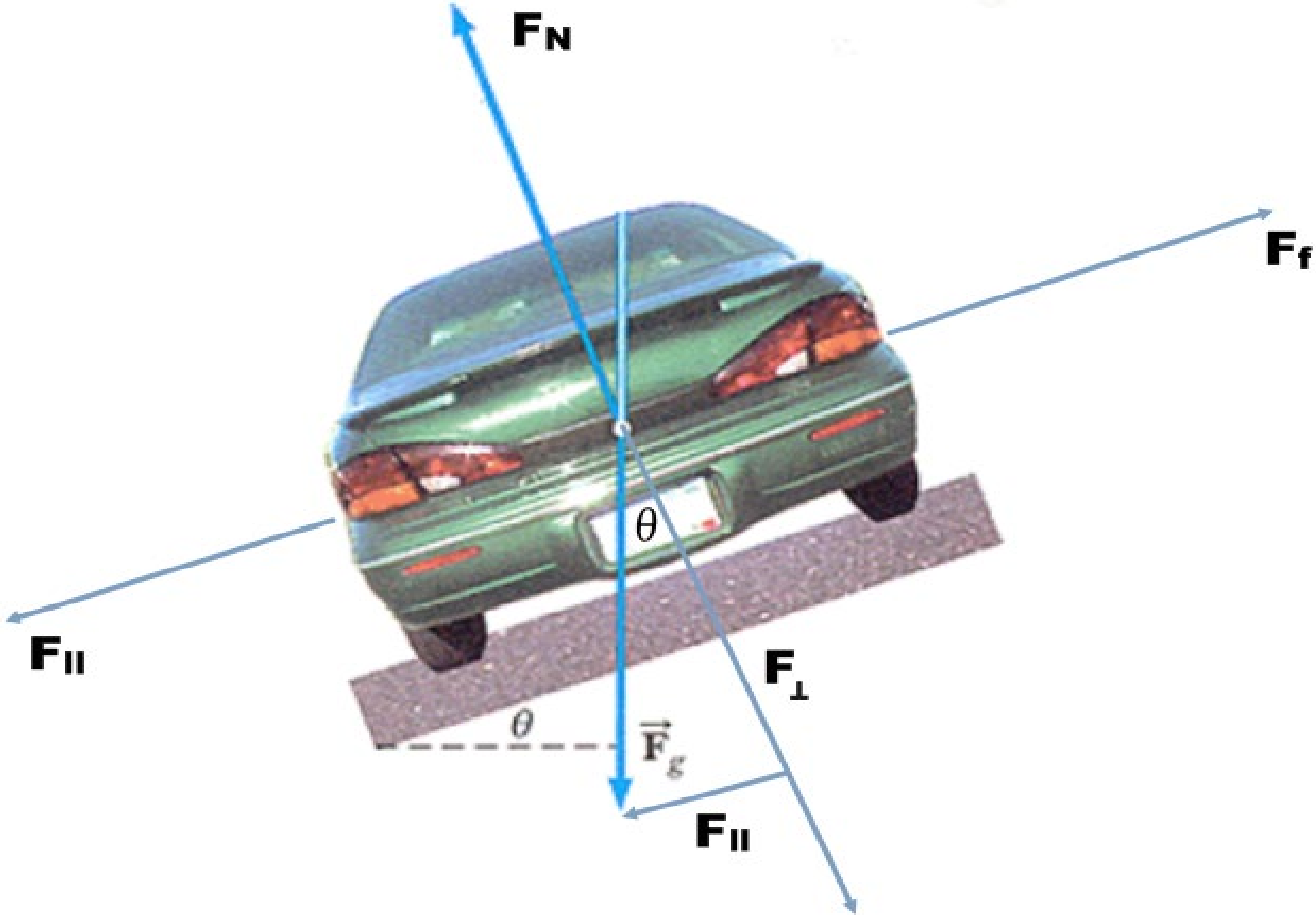
$$F_c = Ff$$

Banked Curves

- When travelling at higher speeds (like on a highway) a simple, level road will not suffice. Why?

- Friction might not be enough to hold the vehicle on the road. We use banked curves (roads raised up at an angle) to keep the car on the road.
- Essentially, the design of a banked curve enlists the help of gravity to keep the car travelling safely around the curve.

We've seen this before...



Banked Curve Formulas

- So:

$$F_c = F_{ll} + F_f$$

- Remember your signs for direction!!

Also, if asked for maximum speed to be able to round the curve at:

- Tan θ = v^2/rg