Course: SPH 4A1
Unit: FORCES

CIRCULAR MOTION IN A VERTICAL PLANE

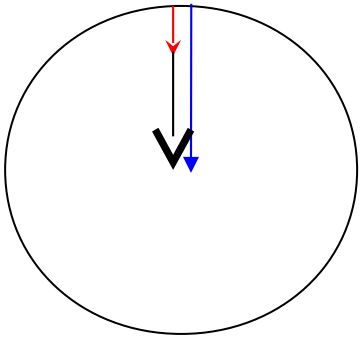
Lesson:

So far we have only looked at motion in a horizontal plane.
Swing the mass in a vertical plane – ask the students what they notice.
If it slows down, where is it the slowest? If I have to pull harder, where is the tension the greatest?
Now try and get force vectors to explain and match our observations:

There are two cases:

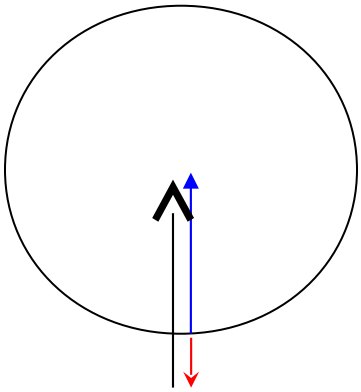
1. **Constant speed.** If the mass is travelling at a constant speed, then Fc must be constant (since $Fc = mv^2/r$ and no other variable are changing).

At the top:



(i) blue arrow = Fc. ⟶
(ii) short red arrow = Fg. ⟶
(iii) ∴the force of tension that is making up the rest of Fc doesn't have to be so large (black arrow) ⟶

At the bottom:



(i) blue arrow = Fc. ⟶
(ii) short red arrow = Fg. ⟶
(iii) ∴the force of tension that is making up the rest of Fc has to be more than normal. It has to pull the mass inward as well as overcome gravity.
(black arrow) ⟶

At the top of a roller coaster, you can feel weightless (instead of tension, you have the normal force of the seat pushing you to the centre), and this force can get quite small).
At the bottom you feel crushed into your seat as you are pulled upwards (right?)

- So tension is continually getting larger and smaller. This causes huge stresses on the frame work (girders?) as a heavy object rotates. This is fixed by using a counterweight (– seen at Canada's Wonderland (name of ride?), Texas oil derricks, steam engine piston/wheels)

- Unless of course you want vibrations to occur. Then a rotating off-centre mass is just what you need.

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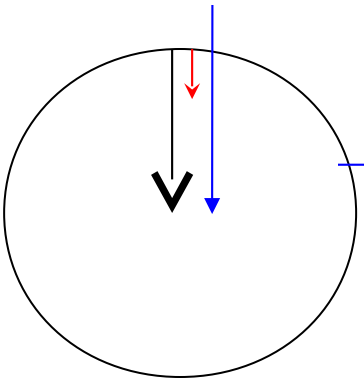
2. Constant Tension: (OMIT. This is theoretical only, I don't know where this can happen)

At the top:



(i) ~~constant tension~~ (black arrow)
(ii) gravity is also ~~pulling~~ downshort red arrow = Fg.
(iii) ~~blue~~ arrow = Fc.

Constant tension means that Fg adds to Ft – as always.
The total Fc would be even greater, ∴ the object would move faster at the top and slower at the bottom.
This particular situation is hard to do because the tension almost automatically gets less.

<insert similar diagram for mass at bottom of curve>

Homework: p133 #4, 7, 8

* Be able to explain to another person why roller coasters use clothoid loops instead of circular loops.
* Where does the word 'clothoid' come from?