Vertical Circles

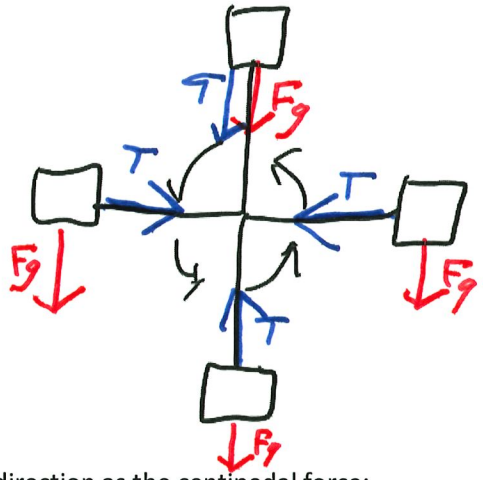
A 0.10 kg mass is connected to a rope and is swung in a vertical circle of radius 0.50 m, at 5.3 m/s.

Determine the centipedal force acting on the mass.

$$F_c = \frac{mv^2}{r} = \frac{0.10\,kg \times (5.3\,m/s)^2}{0.50\,m} = 5.618\,N$$

The mass is affected by both the tension in the rope and the force of gravity.

Draw tension and gravity forces on the block at the different places along the circle.



At the top of the circle, gravity is acting in the same direction as the centripetal force:

$$F_c = T + F_g$$

At the bottom of the circle, gravity is acting in the opposite direction as the centipedal force:

$$F_c = T - F_g$$

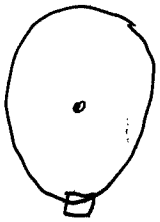
Determine the tension at the top of the circle and bottom of the circle:

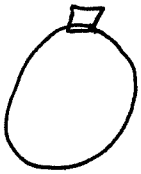
At top $T = F_c - F_g = 5.618\,N - 0.1 \times 9.8 = 4.638\,N \approx 4.6\,N$

At bottom $T = F_c + F_g = 5.618\,N + 0.1 \times 9.8 = 6.6\,N$

PROBLEM: Determine the minimum speed of a mass in a vertical circle.

Consider what will occur if the centripetal force is less than the force of gravity:





EXAMPLE: What is the minimum speed a 2.5 kg object be swung in a vertical circle of radius 0.65 m at?

$$F_c = F_g$$

$$\frac{m v^2}{r} = mg$$

$$v^2 = rg$$

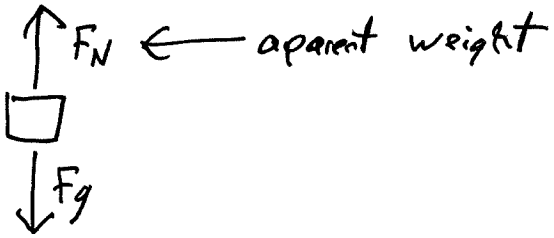
$$v = \sqrt{rg}$$

$$= \sqrt{0.65\,m \times 9.8\,m/s^2}$$

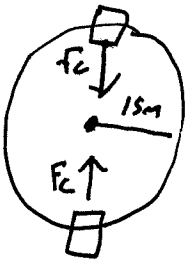
$$= 2.5\,m/s$$

Apparent weight

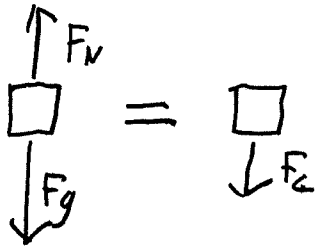
A person standing on a floor is affected by two forces, gravity and the normal force. The force we feel is the normal force, as so we call that force the apparent weight of a person.



EXAMPLE: A person is on a Ferris wheel of radius 15m, which completes a revolution every 85 seconds. Determine their apparent weight at the top and bottom of the Ferris wheel. 63 kg



At top



$$F_g = 63 \times 9.8 = 617.4\,N$$

$$F_c = \frac{63 \times 4 \times \pi^2 \times 15}{85^2} = 5.16\,N$$

$$F_c = \underset{\text{win}}{F_g} - \underset{\text{lose}}{F_N} \rightarrow F_N = F_g - F_c$$

$$= 617.4\,N - 5.16\,N$$

$$= \boxed{612\,N}$$

At bottom $F_c = \underset{\text{win}}{F_N} - \underset{\text{lose}}{F_g}$

$$F_N = F_g + F_c = 617.4\,N + 5.16\,N$$

$$= \boxed{623\,N}$$

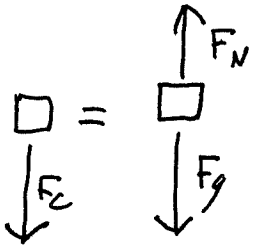
EXAMPLE: A 5.0 kg ball is being swirled in a vertical circle of radius 1.3 m at the minimum speed to keep it in circular motion. What is the apparent weight of the ball at the top, bottom and middle of the circle?

Minimum speed $\rightarrow F_c = F_g$

$$\frac{mv^2}{r} = mg \rightarrow v = \sqrt{rg}$$

$$= 3.5693 \text{ m/s}$$

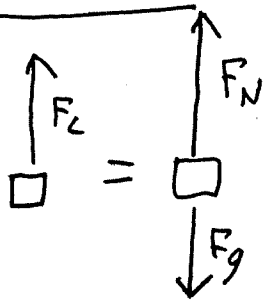
At top



$F_c = F_g - F_N$

But since $F_g = F_c$ $\quad F_N = 0$

At bottom



$F_c = F_N - F_g$

$F_N = F_c + F_g$

$$= \frac{mv^2}{r} + mg$$

$$= \frac{5.0\text{kg} \times (3.5693\frac{\text{m}}{\text{s}})^2}{1.3\text{m}} + 5.0\text{kg} \times 9.8\text{m/s}^2$$

$$= 49\text{N} + 49\text{N}$$

$$= 98\text{N}$$

At middle

All F_c is inward, $F_N = F_g = 49\text{N}$