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Team Introduction

Rollno	Name	contribution to the group activity	Contact Number	PRN
111045	Shardul Anaspure	Explanation	7755932598	1032211784
111056	Shreerang Mhatre	Write Up	9594182016	1032211745
111060	Aman Singh	Diagram & FBD	8169582186	1032211739
111077	Sanat Pawar	Example & conclusion	9372697177	1032211757

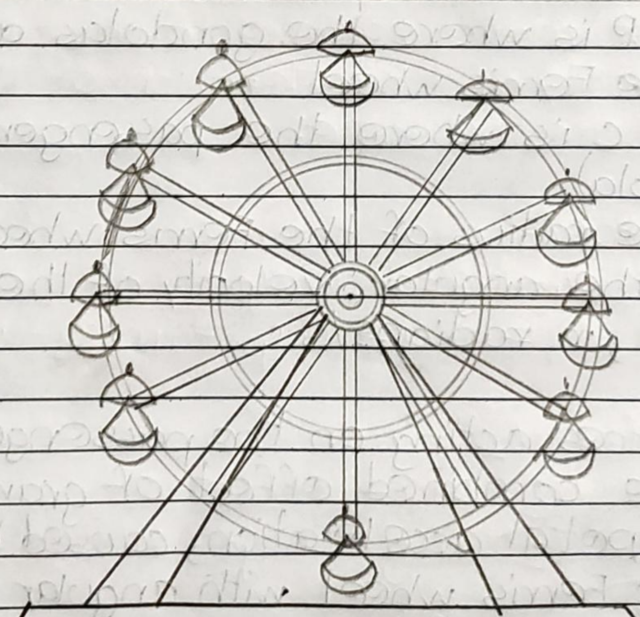
Group Activity

* Report on a Giant wheel in park * or Ferris wheel

* Introduction

The Giant wheel / Ferris wheel consists of an upright wheel with passenger gondolas (seats) attached to the rim. These gondolas can freely pivot at the support where they are connected to the Ferris wheel. As a result, the gondolas always hang downwards at all times as the Ferris wheel spins.

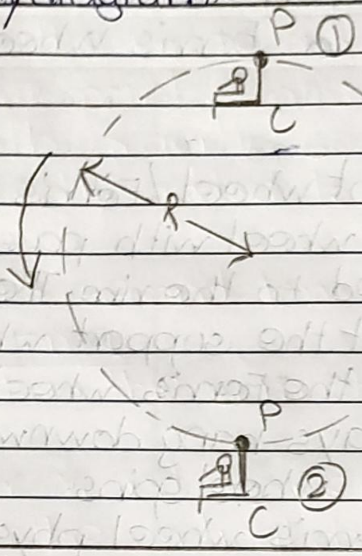
The Ferris wheel physics is directly related to centripetal acceleration, which results in the riders feeling "heavier" or "lighter" depending on their position on the Ferris wheel.



Ferris wheel

* Mechanical /Physical Explanation

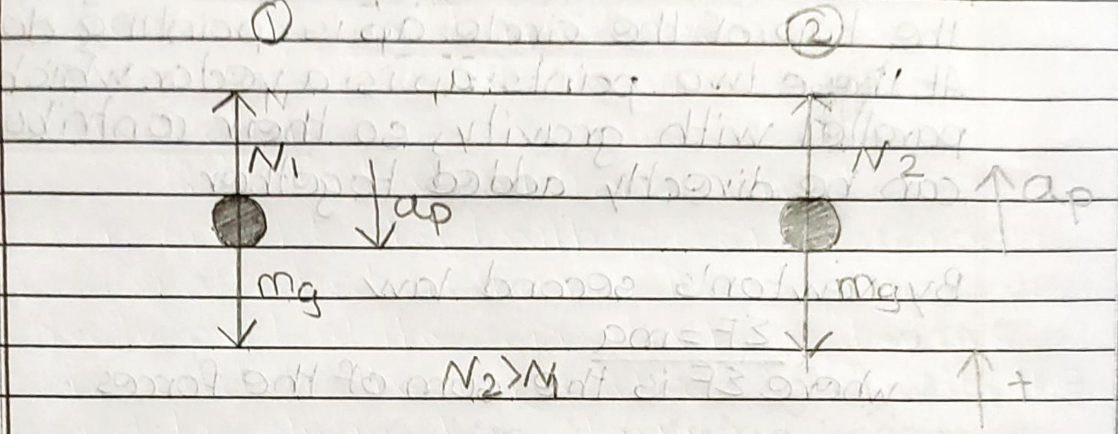
• Free body diagram:-



① From the above diagram:
   ① Is the top-most position and ② is the bottom-most position
② Point P is where the gondolas are attached to the Ferris wheel
③ Point C is where the passengers sit (on the gondola)
④ R is the radius of the Ferris wheel
⑤ W is the angular velocity of the Ferris wheel, in radians/s

• The forces acting on the passengers are due to the combined effect of gravity and centripetal acceleration, caused by the rotation of the Ferris wheel with angular velocity w.

- The figure belows shows a free-body diagram for the passengers at ① & ② locations



Here

① mg is the force of gravity pulling down on the passengers, where m is the mass of the passengers and g is the acceleration due to gravity, which is 9.8 m/s²

② N_1 is the force exerted on the passengers at point C, at location①

③ N_2 is the force exerted on the passengers at point C, at location②

④ a_p is the centripetal acceleration of point P. This acceleration is always pointing towards the center of the wheel. So at location ① this acceleration is pointing directly down, and at location ② this acceleration is pointing directly up.

- The centripetal acceleration is given by

$$\boxed{a_p = w^2 R}$$

- The centripetal acceleration always points towards the center of the circle. so at the bottom of the circle, a_p is pointing up. At the top of the circle a_p is pointing down. At these two points a_p is a vector which is parallel with gravity, so their contributions can be directly added together.

By Newton's second law

$$\Sigma F = ma$$

where ΣF is the sum of the forces.

- To solve for N_1 and N_2 we must apply this equation in the vertical direction.

- The acceleration of the passengers at point C is equal to the acceleration of the Ferris wheel at point P. This is because point C does not move relative to point P. Therefore, the velocity and acceleration of these two points are the same.

Now, for N_1

$$N_1 - mg = m(-a_p)$$

$$N_1 = mg - ma_p = m(g - a_p) \quad \text{— (i)}$$

Now, for N_2

$$N_2 - mg = m(a_p)$$

$$N_2 = mg + ma_p = m(g + a_p) \quad \text{— (ii)}$$

Here, from (i) & (ii)

we can see that $N_2 > N_1$. This means that the passengers feel "heaviest" at the bottom of the Ferris wheel, and the "lightest" at the top.

- Conclusion of mechanical explanation-

The motion of a Ferris wheel affects your bodies "apparent" weight, which varies depending on where you are on the ride. The riders only feel their "true weight", when the centripetal acceleration is pointing horizontally and has no vector component parallel with gravity, and as a result it has no contribution in the vertical direction. This occurs when the riders are exactly halfway between the top and bottom

- Example-

① Lets say we have a Ferris wheel with a radius of 50 meters, which makes two full revolutions per minute.

→ Two full revolutions per minute = 0.21 radians/s

∴ we know that centripetal acceleration is

$$a_p = w^2 R = (0.21)^2 50 = 2.2 m/s^2$$

∴

$$N_1 = m(g - 2.2) \ \& \ N_2 = m(g + 2.2)$$

Put $g = 9.8 m/s^2$, we get

$$N_1 = 7.6m \ \& \ N_2 = 12m$$

by solving further

Hence, at the top, the passengers experience 0.78g i.e they feel ~~he~~ lighter

& at the bottom, the passengers experience 1.2g, i.e they feel heavier.