CUBE NOTES

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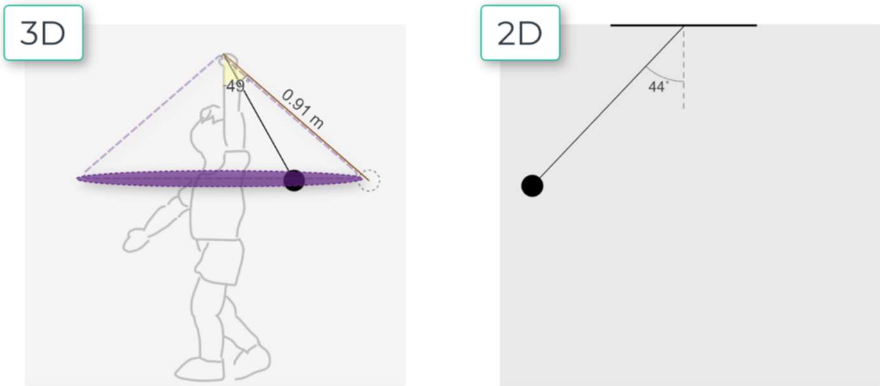
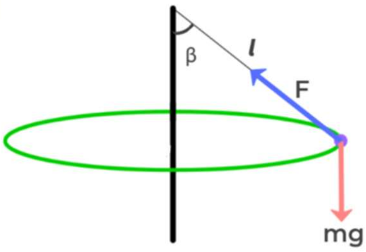
Conical Pendulum

Key Idea:

The conical pendulum is a unique variation from the regular pendulum, where the ball traces a horizontal circle, forming a conical shape. This lesson explores the forces and motion in a three-dimensional plane.

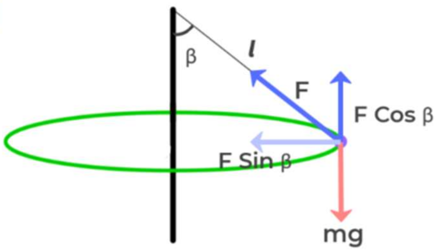


Step 1: Identifying the Forces on the Pendulum Ball



1. **Weight (w)**: Acting vertically downward, w = mg (where m is mass and g is gravity).
2. **Tension (F)**: In the string. We'll use the symbol F for tension to avoid confusion with the time period T.

Step 2: Decomposing the Tension into Components



1. **Vertical Component**: F Cos β
2. **Horizontal Component**: F Sin β

The horizontal component provides the centripetal force for the circular motion.

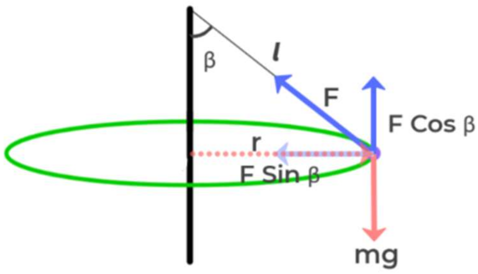
Step 3: Writing the Force Equations

1. **Vertical (YY axis)**: Vertical motion is absent, hence a = 0. Using the Equation

   F = ma

   F Cos β - mg = 0 (YY Direction)

   F Cos β = mg (1)



2. **Horizontal**:

   F Sin β = $m\, a_{radial}$ (2) (XX Direction)

   F Sin β = $\frac{mv^2}{r}$

   (where v is speed, r = l Sin β)

Step 4: Relating Centripetal Acceleration to Angle Beta

Centripetal Acceleration Equation

a_{radial} = (F Sin β)/m from (2)

Substituting F = mg/ Cos β from (1)

a_{radial} = g Tan β (3)

Step 5: Determining the Time Period T of Oscillation

T = Circumference/ Speed = 2 πR / v (time for one revolution)

v = √(gr Tan β) (using $a_{radial} = g \text{ Tan } \beta = \frac{v^2}{r}$)

T = 2 π √(L Cos β/g) (substitute v from above and r = l Sin β)

Observations and Implications

- With fixed L, as β increases, Cos β decreases, shortening T.
- Tension F = mg/Cos β increases with β.
- A 90-degree swing is impossible (T would be zero, F and v infinite).