Circular Motion & Torque

Circular Motion

- centripetal acceleration
- frequency
- period
- law of universal gravitation

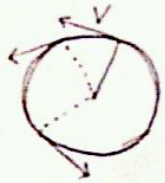
Formulas

$$a_r = \frac{v^2}{r}$$

$$F_r = \frac{mv^2}{r}$$

$$F_{grav} = G\frac{M_1 M_2}{r^2} \quad ; \quad T = \frac{1}{f} \quad ; \quad v = \frac{2\pi r}{T}$$

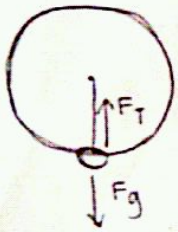
Diagrams



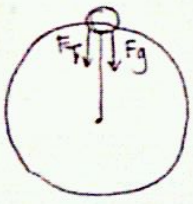
velocity is tangential.

circular motion

- vertical

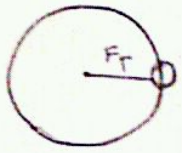


$F_c = F_{net} = F_T - F_g$



$F_c = F_{net} = F_T + F_g$

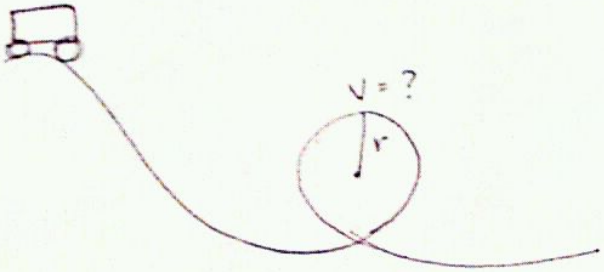
· horizontal



$F_C = F_T$

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

Examples

① 

$mgh + \frac{1}{2}mv^2 = mgh + \frac{1}{2}mv^2$

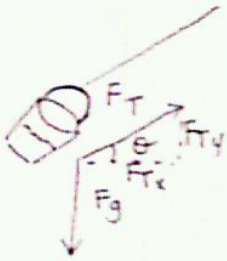
(0 when maximum)

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

$\frac{v^2}{r} = g$

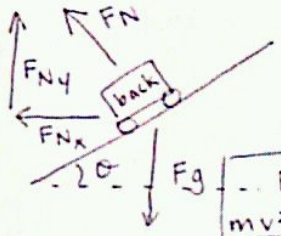
$v = \sqrt{gr}$

$mgh_1 + \cancel{\frac{1}{2}mv^2}^{0} = mgh_2 + \frac{1}{2}m(\sqrt{gr})^2$

② 

$F_C = F_{Tx}$

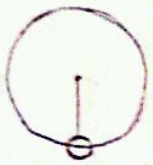
$\frac{mv^2}{r} = F_T \cos\theta$

③ 

$F_C = F_{Nx}$

$\frac{mv^2}{r} = mg \sin\theta$

MCQ

1) 

A 2 kg ball is spun vertically in a circle. The velocity at the bottom of the circle is $\sqrt{2}$ m/s. If the tension in the string is 30N, what is the length of the string? (Assume $g = 10\ m/s^2$)

a. 0.3 m/s b. 0.4 m/s c. 0.6 m/s d. 0.47 m/s

2) Why doesn't an object in circular motion move in the direction of the centripetal force?

a. The object does move in the direction of the centripetal force.

b. The net force is 0, thus, there is no movement of the object.

c. Gravity is ineffective.

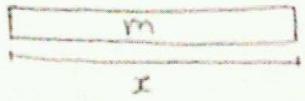
d. The velocity and acceleration are both constantly changing.

Torque

lever arm (r)

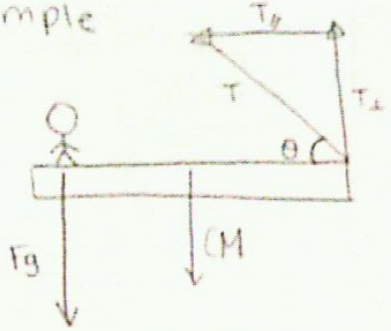
$$\tau = rF\sin\theta = r_\perp F = rF_\perp$$

Center of mass (CM)



$$\tau = rF$$
$$\tau = \left(\frac{x}{2}\right)(mg)$$

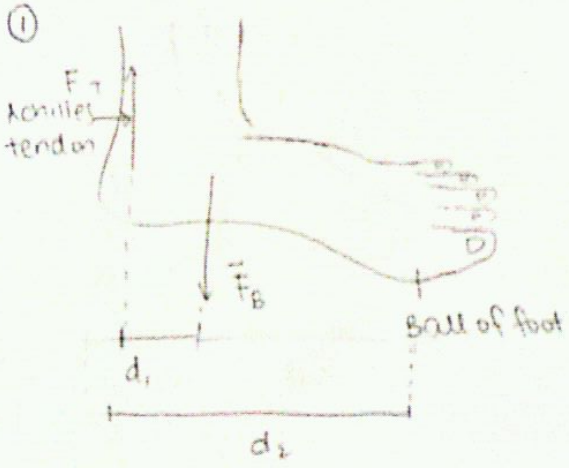
Example



When stable

$$\Sigma\tau = 0 = F_g + CM - T_\perp$$

①



When a person elevates himself on the "ball of one foot," what is the tension F_T in the Achilles tendon? Assume $d_1 = 3$ cm and $d_2 = 10$cm & the person has a mass of 65 kg

a) 446 N b) 2120 N c) 637 N d) 1490 N

$\therefore T_{\text{of vendor}} = T_{\text{of wall of foot}}$

$F_T \cdot DB = 0.07 \times 9.8 \times 65$

$F_T = 1490N$