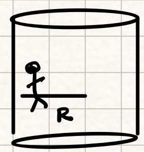
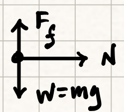
Correction: For static friction $\quad 0 < F_f \le \mu N$

Example: Spinning Terror:





$$N = m R\omega^2$$

↳ Radial acceleration

$$F_f = mg$$

$$F_f < \mu N = \mu m R\omega^2$$

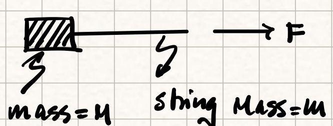
$$\cancel{m}g < \mu \cancel{m} R\omega^2$$

$$\omega^2 > \frac{g}{\mu R}$$

For $\mu = 0.5$ & $R = 10$ meters $\quad \omega_{min} \sim 1.4$ rad/sec

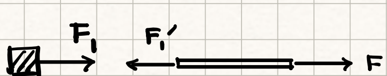
$$\omega = 2\pi f \Rightarrow f = \omega/2\pi = 0.22\ s^{-1} = 16.2\ min^{-1}$$

String Tension:



Combined system is being pulled by force F. What is the force on the block due to string?

We ignore gravity.



$$F - F_1' = m a_s$$

$$F_1' = F_1 \quad \text{and} \quad a_s = a_M$$

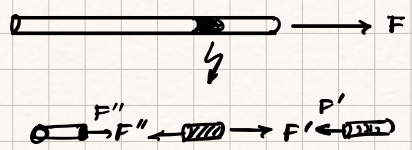
$$F_1 = M a_M$$

$$F = (M+m)\,a \Rightarrow a = \frac{F}{(M+m)}$$

$$F_1 = \frac{M}{(M+m)} F$$

$\Rightarrow \quad F_1 < F$

If $\quad M >> m \Rightarrow \quad F \approx F_1.$



Net force on any point on string is zero. $|F(x)|$ is tension.

<u>Viscosity</u>: The resistance force felt by a body moving through a fluid

$$\vec{F}_v = -c\vec{v}$$

$\vec{v} \rightarrow$ Velocity of a moving object. $c \rightarrow$ Coefficient of viscosity.

$c \rightarrow$ sphere of radius r moving through air/water

$$c = 6\pi\eta r$$

$\eta \rightarrow$ Dynamic Viscosity

$$\boxed{F = 6\pi\eta r v} \quad \text{Stoke's Law.}$$

$$[\eta] = ML^{-1}T^{-1}$$

Example: Terminal velocity of a small spherical droplet falling through air:

$$m\frac{dv}{dt} = -6\pi\eta r v + mg$$

$$\Rightarrow \frac{dv}{dt} = \frac{-6\pi\eta r}{m}v + g$$

For a droplet:

$$m = \frac{4}{3}\pi r^3 \rho_w$$

$$\frac{dv}{dt} = -\overset{3}{\cancel{6}}\cancel{\pi}\eta\cancel{r} \cdot \frac{3}{\underset{2}{\cancel{4}}\cancel{\pi} r^{\cancel{3}\,2}\rho_w} v + g$$

$$= -\frac{9}{2}\left(\frac{\eta v}{\rho_w r^2}\right) + g$$

If the initial velocity $v=0$ The velocity will increase unit $\frac{dv}{dt}=0$

$$\Rightarrow \quad v_t = \frac{2}{9} \frac{g \rho_w r^2}{\eta}$$

For water droplets: $\rho_w = 1000 \ kg/m^3$

$\eta = 1.8 \times 10^{-5} \ kg/m \cdot s$

$r = 5 \times 10^{-6} m$

$$\Rightarrow \quad v_t = 3 \times 10^{-3} m/s.$$