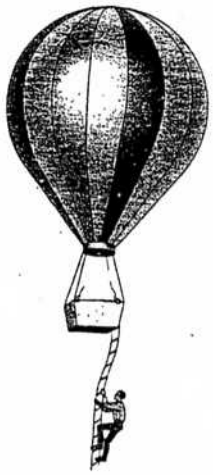
example

A man of mass m clings to a rope ladder suspended below a large hot air balloon of total mass M (including the basket and the ladder). The balloon and the man are initially stationary relative to the ground. If the man begins to climb up the ladder at a given constant speed v relative to the ladder, **(a) in what direction and at what speed relative to the ground will the balloon move?** Any gravitational effects are not relevant in this problem. **(b) If the man then stops climbing, what is the speed of the balloon?**



a). $(m+M)$ system

$$\vec{F}^{\,0}_{net\ ext} = (m+M)\,\vec{a}_{cm}$$

$$\vec{a}_{cm} = 0$$

$$\vec{a}_{cm} = \frac{d\vec{V}_{cm}}{dt}$$

$$\vec{V}_{cm} = \text{constant} = 0$$

(initially stationary)

The center of mass doesn't move.

$$V_{cm} = \frac{mV_{mg} + MV_{bg}}{m+M} = 0$$

equation: $\therefore\ mV_{mg} + MV_{bg} = 0$

relative velocity: $V_{mg} = V_{mb} + V_{bg} = V + V_{bg}$

$$m(V + V_{bg}) + MV_{bg} = 0$$

$$\downarrow\ V_{bg} = -\frac{mV}{m+M}\ \uparrow$$

the balloon moves downward direction if the man climbs up

b). when the man stops. $V=0$. then balloon stops