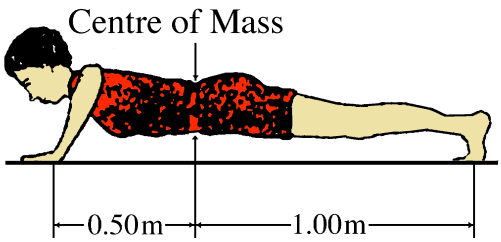
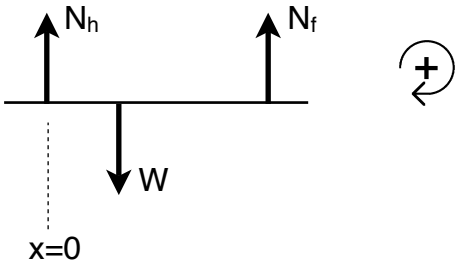
# Push-up

A 65 kg woman is horizontal in a push-up position.

What are the vertical forces acting on her hands and her feet?




**Solution**: There are three forces acting (all in the vertical direction): the weight, and two normal forces, at her hands and feet.

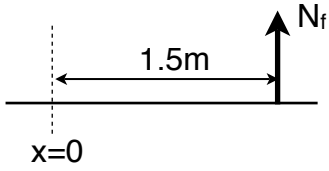



The woman is stationary, so there is no net force acting; hence

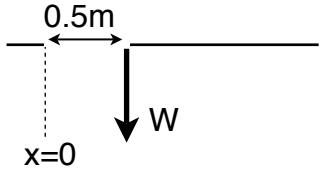
$$N_h + N_f - W = 0$$

Because she is in equilibrium, there is no net torque on the woman around **any** point. Take her hands to be the pivot point, and take torques in the clockwise direction to be positive. Now for each force, draw the line of action and find the torque around this axis.

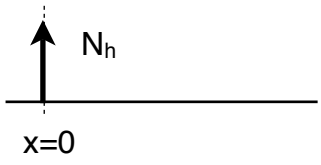
- Torque due to $N_f$: acting at distance 1.5m in **negative** direction so $\tau_f = -1.5N_f$




- Torque due to W: acting at distance 0.5m in **positive** direction, so $\tau_f = +0.5W$




- Torque due to $N_h$: acting at distance 0 so $\tau_h = 0$




Because she is in equilibrium, $\Sigma\tau = 0$

so $0.5mg - 1.5N_f = 0$

so re-arranging:

$N_f = 0.5/1.5\ mg = \frac{1}{3}\ mg$

$= \frac{1}{3} \times 65 \times 9.8 = 212$ N (the vertical force acting on her feet)

and so from the force equation,

$N_h = mg - N_f = mg - \frac{1}{3}\ mg = \frac{2}{3}\ mg$

$= 425$ N (the vertical force acting on her hands)