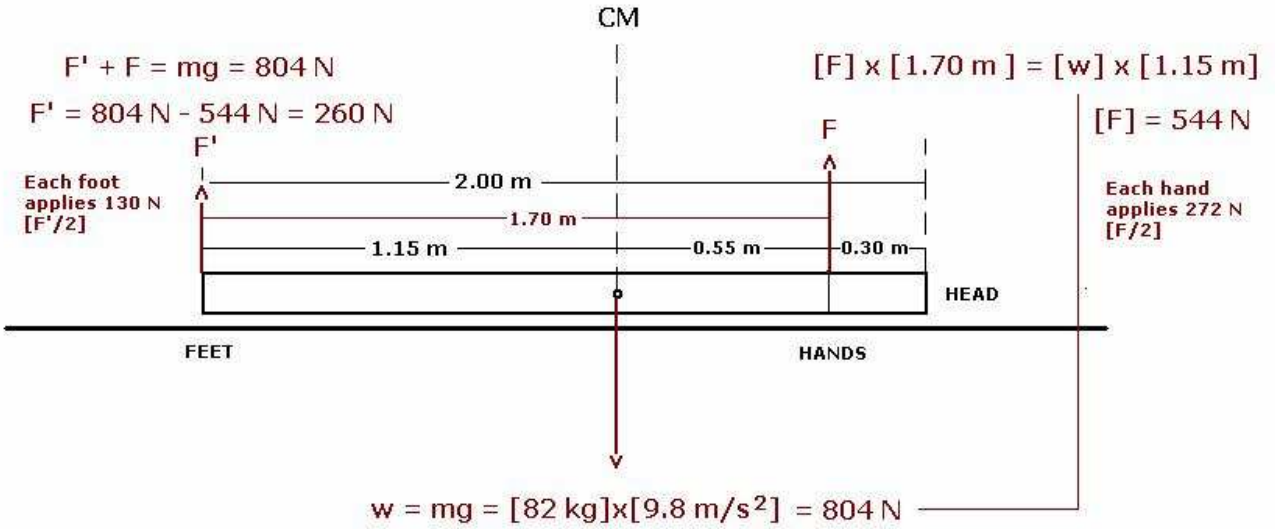
39. Push-ups. To strengthen his arm and chest muscles, an 82 kg athlete 2.0 m tall is doing a series of push-ups as shown in Figure 10.58. His center of mass is 1.15 m from the bottom of his feet, and the centers of his palms are 30.0 cm from the top of his head. Find the force that the floor exerts on each of his feet and on each hand, assuming that both feet exert the same force and both palms do likewise. Begin with a free-body diagram of the athlete.



The athlete's arms apply a force F at a lever-arm distance of 1.70 m [measured from the feet which do not rise but just pivot] to produce the torque required to lift his body. The product of F and 1.70 m [the applied torque] must equal the product of the athlete's weight [w] and the distance from the pivot [feet] to the center of mass [CM]. The CM should be imagined as the point at which all the mass of a body is concentrated. The weight vector [w] is always drawn vertically downward from the CM. The sum of the torques around the CM is always zero when in rotational equilibrium. Solving for the force applied by the floor to his arms [F] yields 544 N. Since the athlete is in a state of equilibrium, the sum of all the forces acting on his body must be zero. Hence the force applied by the floor against his arms [F] plus the force applied by the floor to his feet [F'] must equal the magnitude of the weight [w] [F + F' = -w]. Note the weight is in an opposite direction of F and F'. Hence F' = 260 N. The free-body diagram has three arrows, one upward at the arms [F], one upward at the feet [F'] and one downward from the CM [w].

Hope this helps.