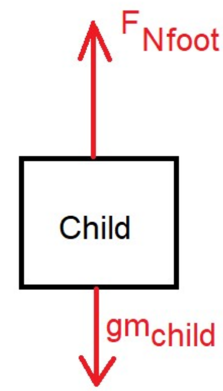
9-34)

This is an example of a poorly written question. First, the figure in the textbook omits two forces: that of the knee joint on the lower leg and the force of the child on the leg. So, we need to deal with five forces. We'll also need to look at forces acting on the child. Then, there is the issue of what 'constant speed' means; is the child moving vertically, in which case the leg is accelerating rotationally, or is the child moving at constant speed around a circle, in which case there must be some force on it directed centripetally. O.K., *let's change the problem so that the child is merely held in place by the father's leg*.

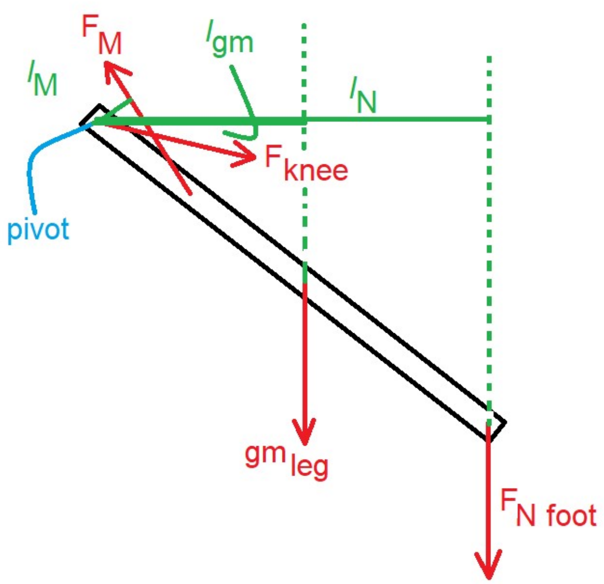


First, the child:

$$-gm_{\text{Child}} + F_{\text{N Foot}} = m_{\text{Child}} a_{\text{Child,y}} = 0 \ ,$$

$$F_{\text{N Foot}} = gm_{\text{Child}} = 10(10) = 100 \text{ N} \ ,$$

which tells us what we probably could guess, that the child exerts a force of 100 N downward on the end of the father's leg.



Now for the leg. Let's look at torques first, because that may be enough. We have the normal force exerted by the child on the foot, the weight of the leg, the force of the knee, which must be directed down and to the right, and the force applied by the muscle, upward and to the left as shown in the figure in the book. For each of these, we are given the level arm.

We know the least about what's going on at the knee joint, so let's make that the pivot. For several of the applied forces, we are given the corresponding lever arms, so,

$$\sum_n \tau_n = (0)F_{\text{Knee}} + l_M F_M - l_{\text{gm Leg}} gm_{\text{Leg}} - l_N F_N = 0$$

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$$l_M F_M = l_{\text{gm Leg}} gm_{\text{Leg}} + l_N F_N$$

$$F_M = \frac{l_{\text{gm Leg}} gm_{\text{Leg}} + l_N F_N}{l_M} = \frac{0.2 \times 10 \times 4 + 0.38 \times 100}{0.02} = 2300 \text{ N}$$