

# Introduction to Biomechanics VU 317.043

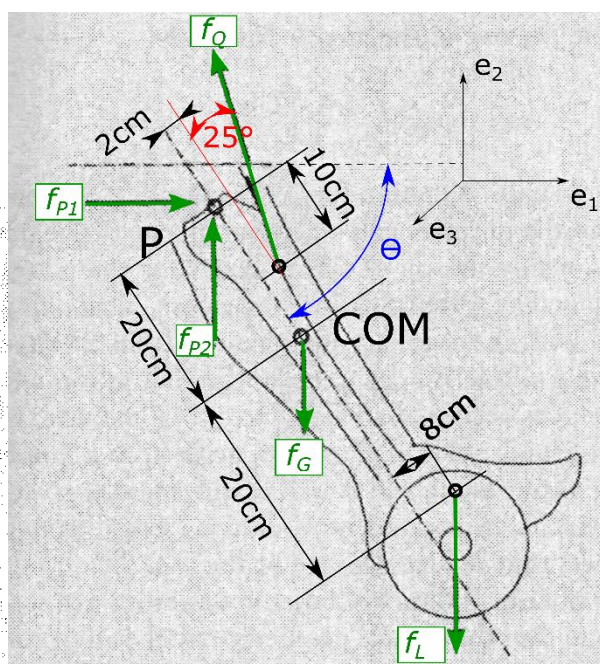
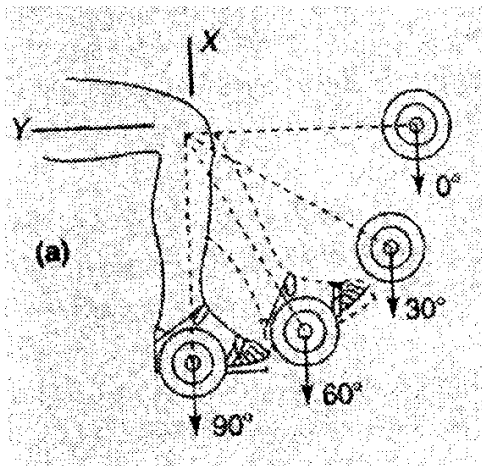
## Tutorial 2

27.10.2021

### 1 Knee Joint

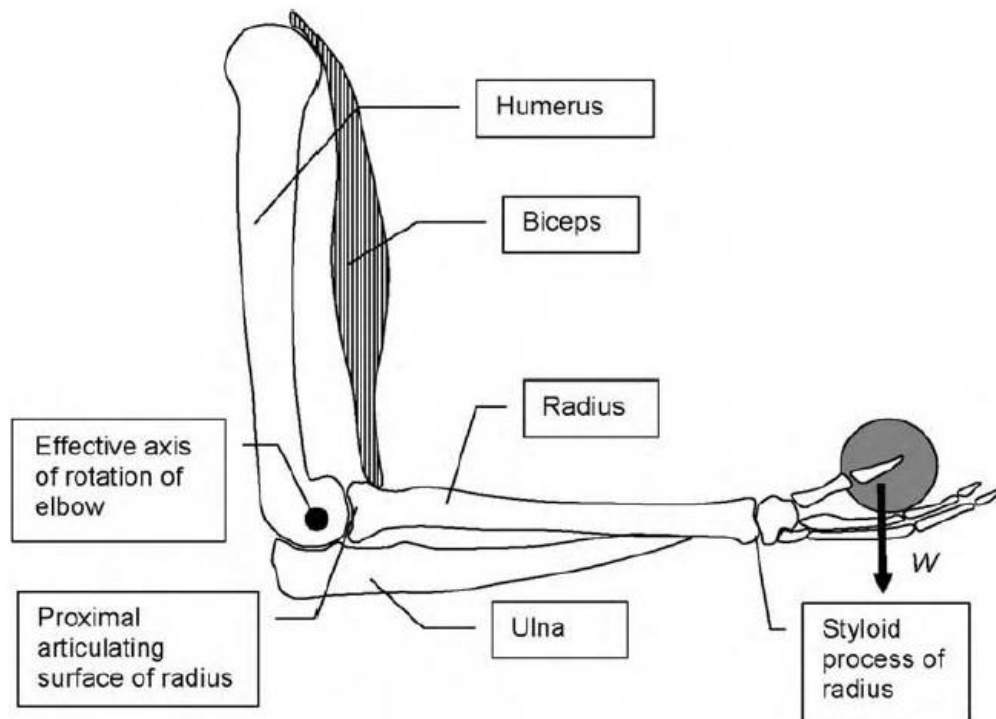
Consider a simple strengthening exercise for the quadriceps, as illustrated in the left figure below. The weight is lifted by the lower leg at different angles. Use the free body diagram in the right figure to answer the following points:

- Derive an expression for the muscle tension  $f_Q$  of the quadriceps required for static equilibrium as a function of the flexion angle  $\Theta$
- Determine the reaction forces in joint  $P$
- For  $f_L = 120\text{ N}$ ,  $f_G = 30\text{ N}$  and  $\Theta = 0^\circ, 30^\circ, 60^\circ, 90^\circ$  calculate the required muscle tension.
- Sketch  $f_Q(\Theta)$  (with the inserted force values) from  $\Theta = 0^\circ$  to  $90^\circ$



## 2 Elbow Joint

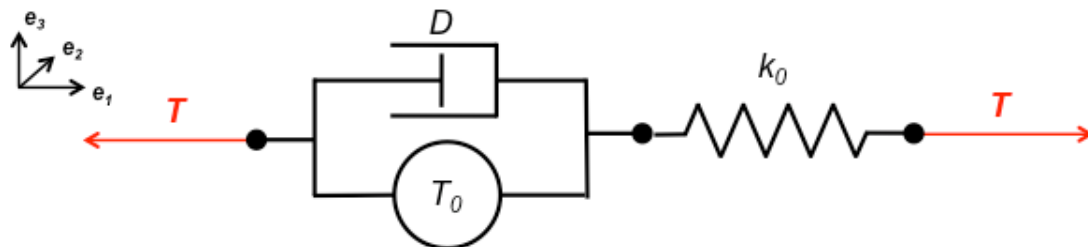
Consider the following simplified diagram of an arm holding a weight. Calculate the force exerted by the biceps on the radius in order to hold the arm plus a weight of 2 kg in place.



Begin by drawing an appropriate free body diagram. Estimate all the lengths and weights needed for your calculation. For this you can either research literature or measure on your own arm. In any case you need to be able to justify our assumptions.

### 3 Muscle lumped parameter model

Consider the three-element model of a muscle:



The contractile element produces a constant tension  $T_0$  during activation – otherwise it produces no tension.

- For an isometric contraction derive an expression for  $T(t)$ , assuming that the contractile element is activated from  $t = 0$  until  $t = C$ .
- Sketch  $T(t)$

### 4 Pennate Muscle

Prove that the force generated (per unit depth) of a pennate muscle arrangement (as per the sketch below) is:

$$F_{\text{pennate}} = 2wf_{\text{fiber/area}}l \cos(a) \sin(a)$$

