

1. The members of the mechanism are pin-connected at their centers as shown in Figure 1. The member length $AC = DE = 2$ m. Two vertical forces F_1 and F_2 act at E and C as shown. The spring is unstretched when $\theta = 45^\circ$. The spring constant $k = 400$ N/m. Neglect the weight of the members.

- (a) If $F_1 = F_2 = F$, draw the free body diagrams for the members AC and DE . (10 分)
- (b) If $F_1 = F_2 = F$, plot the F vs. θ graph (range: $0^\circ < \theta < 45^\circ$). (10 分)
- (c) Set $F_1 = F_2 = 30$ N, determine the θ for stable equilibrium. (10 分)
- (d) Set $F_1 = 0$ N and $F_2 = 60$ N, determine the θ for stable equilibrium. (10 分)

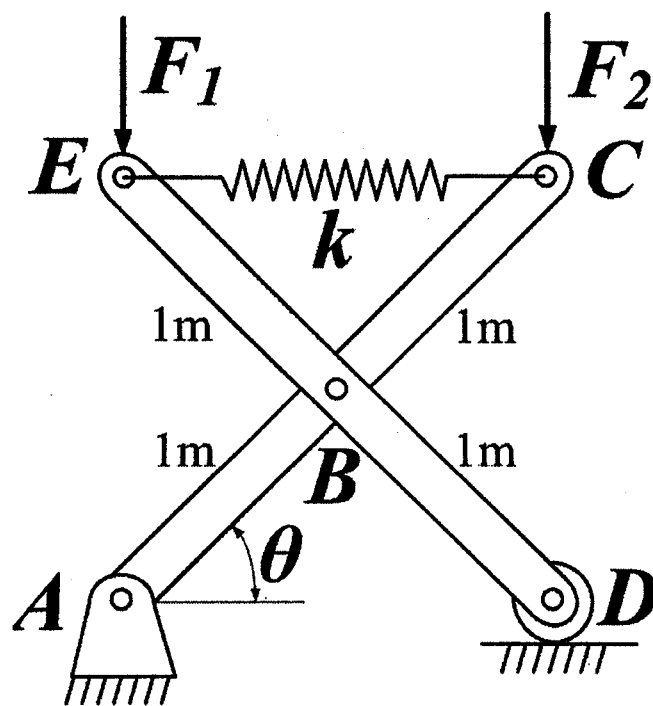


Figure 1

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2. The maximum tension that can be afforded in the chord shown in Figure 2 is 300 N. The pulley at A is free to rotate and the coefficient of static friction at the fixed drums B and C is $\mu_s = 0.3$. Assume that the force T applied at the end of the chord is directed vertically downward. Determine the largest mass of the cylinder that can be lifted by the chord. (30 分)

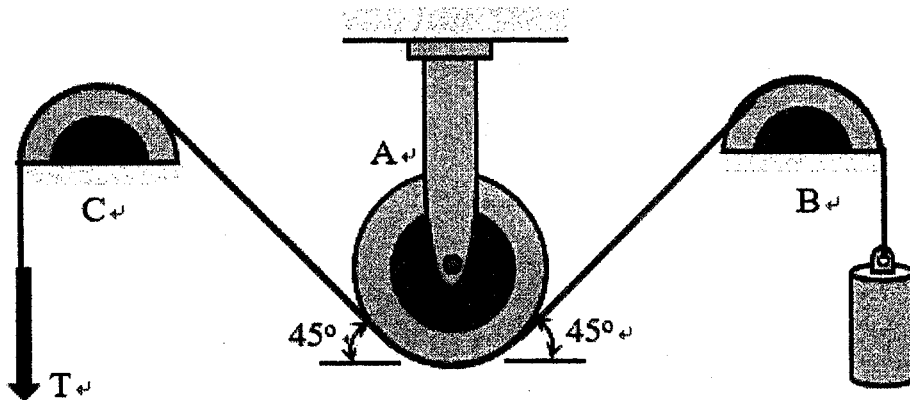


Figure 2

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3. Figure 3-1 below depicts a human lower limb as a 3-link model connected by frictionless revolute joints. 11 muscles are chosen to be included for human movement modeling as shown in Figure 3-2 with muscles RF: rectus femoris, ST: semitendinosus, SM: semimembranosus, CL: biceps femoris caput longum, TA: tibialis anterioris, IL: iliacus, CB: biceps femoris caput breve, SO: soleus, GL: glutei, VA: vasti, GA: gastrocnemius. Figures 3-3(a), 3-3(b), and 3-3(c) represent the segments of the lower limb thigh, shank, and foot, respectively. Each segments are shown with muscles as indicated. For example, the foot (3-3(c)) has three muscles TA, SO, and GA at different locations. The distal side indicates away from the main mass of the body. Taking Fig.3-3(c) as an example, the distal side of the foot denotes the toes.

(a) Draw the free body diagram of the thigh (4 分) and derive the equations of motion (6 分)

(b) Draw the free body diagram of the shank (4 分) and derive the equations of motion (6 分)

(c) Draw the free body diagram of the foot (4 分) and derive the equations of motion (6 分)

Please use the notations of forces shown below to derive the equations of motion of the thigh, shank, and foot.

F_1 Force of muscle rectus femoris

F_2 Force of muscle semitendinosus

F_3 Force of muscle semimembranosus

F_4 Force of muscle biceps femoris caput longum

F_5 Force of muscle tibialis anterioris

F_6 Force of muscle iliacus

F_7 Force of muscle biceps femoris caput breve

F_8 Force of muscle soleus

F_9 Force of muscle glutei

F_{10} Force of muscle vasti

F_{11} Force of muscle gastrocnemius

$R_{1,x}$ Horizontal component of reaction force at hip

$R_{1,y}$ Vertical component of reaction force at hip

$R_{2,x}$ Horizontal component of reaction force at knee

$R_{2,y}$ Vertical component of reaction force at knee

$R_{3,x}$ Horizontal component of reaction force at ankle

$R_{3,y}$ Vertical component of reaction force at ankle

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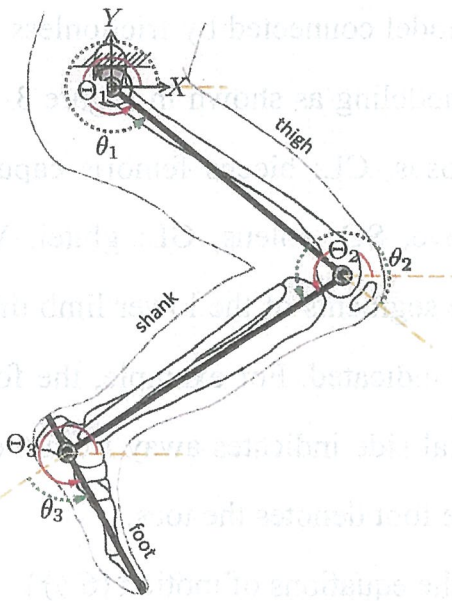


Figure 3-1 : The human lower limb depicted as a 3-link model with revolute joints.

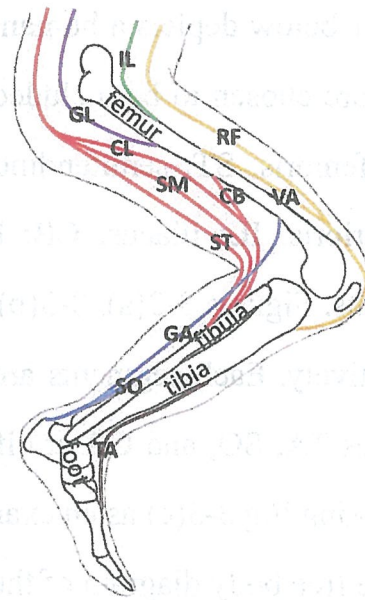


Figure 3-2 : Position of 11 muscles on the lower limb.

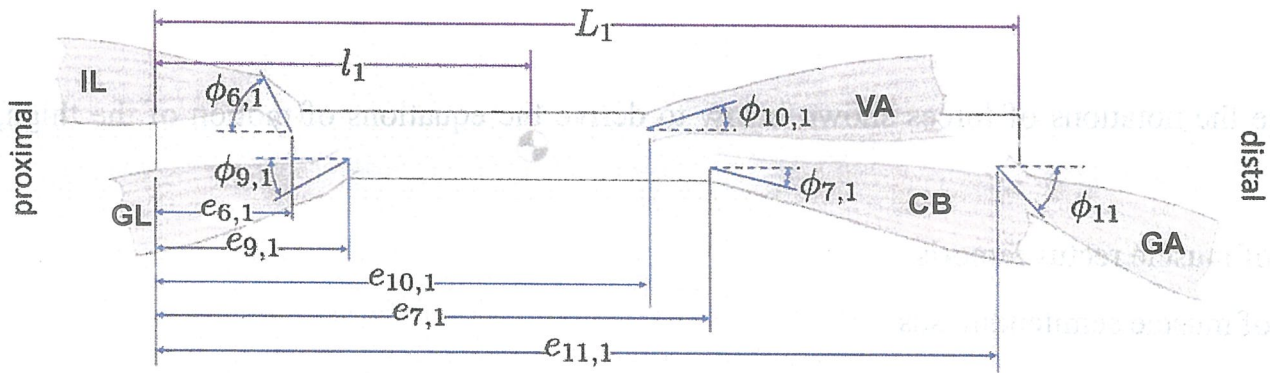


Figure 3-3(a) : Segment (Thigh) of the lower limb

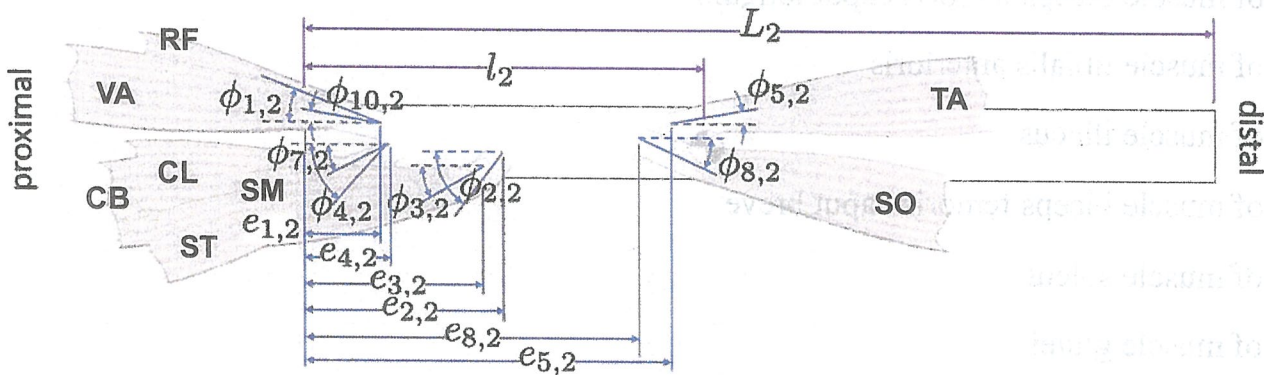


Figure 3-3(b) : Segment (Shank) of the lower limb.

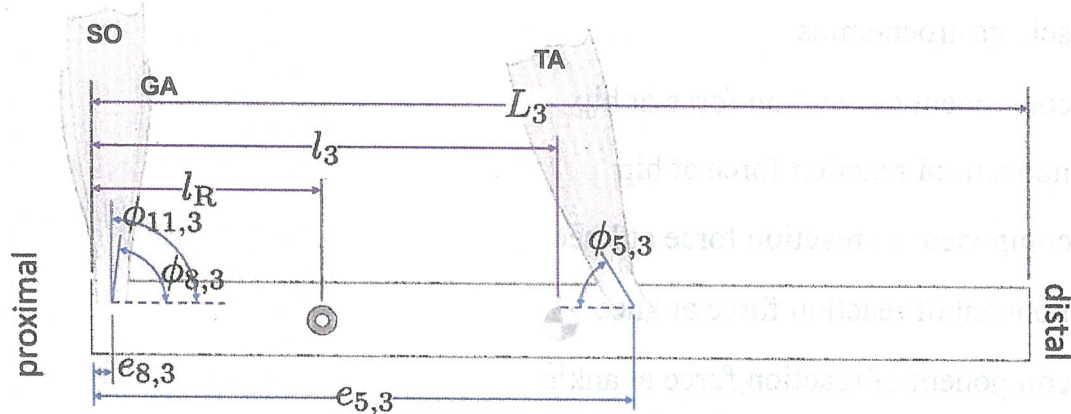


Figure 3-3(c) : Segment (foot) of the lower limb.

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