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國立成功大學八十二學年度醫學工程研究所入學考試(工程力學 試題)

1. (20 %) A person seated on a table, with the back placed against a back rest and the knees at the edge. The subject was then asked to extend the lower leg as rapidly as possible. The angular displacement (θ) of the lower leg was measured from its initial vertical position by an electrogoniometer. Using a finite difference technique, the angular velocity (ω) and angular acceleration (α) of the lower leg were also calculated. Some of the forces acting on the lower leg are shown in Figure 1, along with the geometric parameters of the model under consideration. Notice that the model is based on the assumption that *the quadriceps muscle is the primary mover*. The patellar tendon is attached to the tibia at A, which is located at a distance a from the instantaneous center of rotation (O) of the lower leg about the knee joint. The total weight of the lower leg is W and its center of gravity is located at B, a distance b from O. The line of pull of the patellar tendon force makes an angle β with the long axis of the tibia. The intended direction of motion is counterclockwise. Assume that $W = 50$ N, $a = 5$ cm, $b = 22$ cm, $\beta = 24°$, and the mass moment of inertia of the lower leg about the knee joint is $I_o = 0.25$ kg-m^2, determine
   (a) the magnitude of the net torque produced by the knee extensor muscles,
   (b) the rotational component (F_{mt}) of the tension in the patellar tendon (assume the result of (a) is due to the rotational component),
   (c) the tension in the patellar tendon,
   (d) the reaction force at the knee joint at an instant when $\theta = 60°$, $\omega = 5$ rad/s, and $\alpha = 200$ rad/s^2.

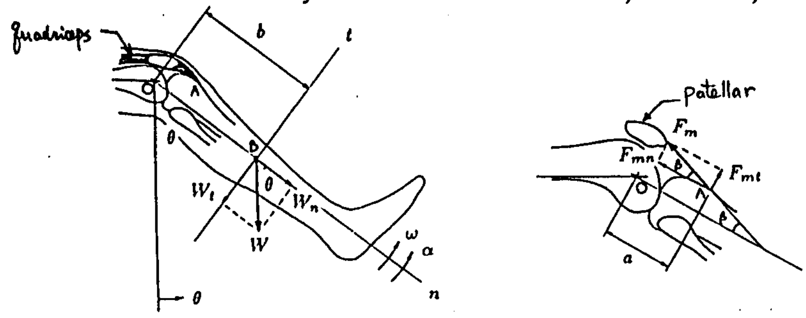

Figure 1: Some of the forces acting on the lower leg.

2. (20 %) *Euler angles* are often used to describe relative rotations of one segment with respect to another reference segment in a three-dimensional space. These angles are defined as a set of three finite rotations assumed to take place in sequence to achieve the final orientation from a reference orientation. The orthopedic angles describing the lower extremity limb rotations in gait analysis are defined as follows (Fig. 2): First, a particular segment rotates in the right-handed direction through an angle θ_1 about the reference **Y** axis. At this point, the new orientation of the embedded axes of the moving segment is denoted by $\mathbf{X}_1$, $\mathbf{Y}_1$, and $\mathbf{Z}_1$. Then the segment rotates in the right-handed direction through an angle θ_2 about the reference $\mathbf{X}_1$ axis. The new orientation of the axes of the moving segment is now denoted by $\mathbf{X}_2$, $\mathbf{Y}_2$, and $\mathbf{Z}_2$. Finally, the segment further rotates through an angle θ_3 about the new $\mathbf{Z}_2$ axis to achieve its final position. Three orthogonal unit vectors **I**, **J**, and **K** are along the embedded **X**, **Y**, and **Z** axes, respectively. Three orthogonal unit vectors $\mathbf{I}_3$, $\mathbf{J}_3$, and $\mathbf{K}_3$ are along the embedded $\mathbf{X}_3$, $\mathbf{Y}_3$, and $\mathbf{Z}_3$ axes, respectively. The two coordinate systems can be transformed following the matrix relationship:

$$\begin{bmatrix} \mathbf{I}_3 \\ \mathbf{J}_3 \\ \mathbf{K}_3 \end{bmatrix} = [A] \begin{bmatrix} \mathbf{I} \\ \mathbf{J} \\ \mathbf{K} \end{bmatrix}$$

(a) Derive the transformation matrix [A] in terms of θ_1, θ_2, and θ_3. (b) Are Euler angles unique?

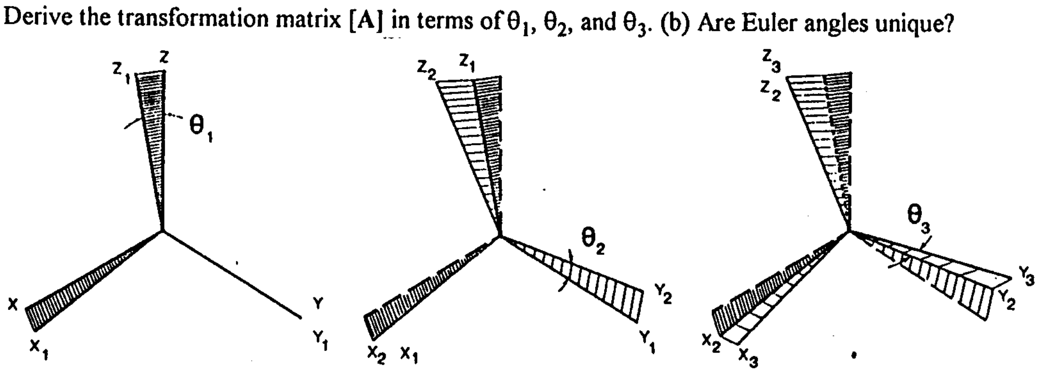

Figure 2: Euler angles.

3. (10 %) (a) What is *kinematics*? How can it be applied in the analysis of human movement? Illustrate.
   (b) What is *kinetics*? How can it be applied in the analysis of human movement? Illustrate.

4. The patient weighs 70 kg. His heels produce a force of 100 N against the force plate. The remaining weight is distributed equally between his two hands. Figure 4 graphically illustrates the line of application, point of application, and direction of the reaction force on the right hand during a sitting push-up. Find the external torque(M) on the elbow joint. (10%)

5. Figure 5 shows the weights of the individual body segments and the lengths of their moment arms relative to the center of rotation of the hip joint. Find a) the external torque(M) on the hip joint during an active leg lift with the patient supine and the knee fully extended, b) the horizontal distance from the center of rotation of the hip to the common center of gravity of the three body segments. (15%)

6. The 26 x 30 in. plate ABCD is supported by hinges along edge AB and by wire CE. Knowing that the plate is uniform and weighs 100 lb, determine the tension in the wire. (see Figure 6) (15%)

7. Determine the components of all forces acting on member ABCD shown in Figure 7 when $\theta = 0$ and 150 N force acts at point F. (10%)

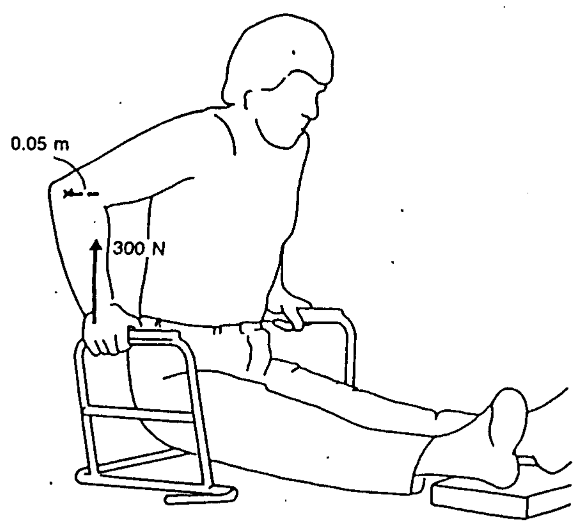

Figure 4

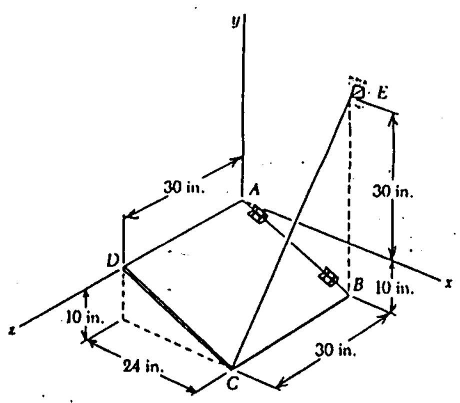

Figure 6

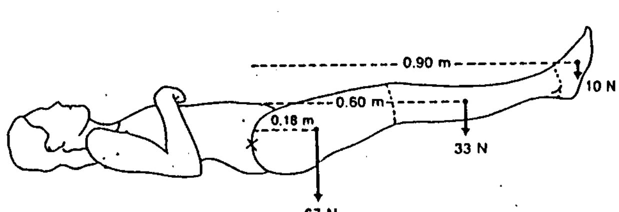

Figure 5

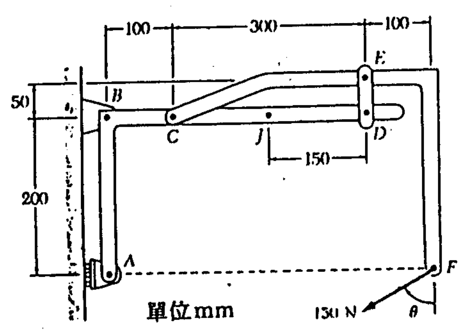

Figure 7