1. A scale mechanism is shown in the Figure 1. The attached spring has an unstretched length W of 50 mm and a spring constant k of 0.1 N/mm. The length L is 100 mm. Neglect the weights of the beams.

(a) Draw the free body diagram for the beam AB. (10 分)

(b) Determine the angle θ for equilibrium when a load F = 10 N is applied at the center. (note: $\theta \neq 0$) (15 分)

(c) Plot the F vs. θ graph (range of θ : $0^\circ < \theta < 90^\circ$). (15 分)

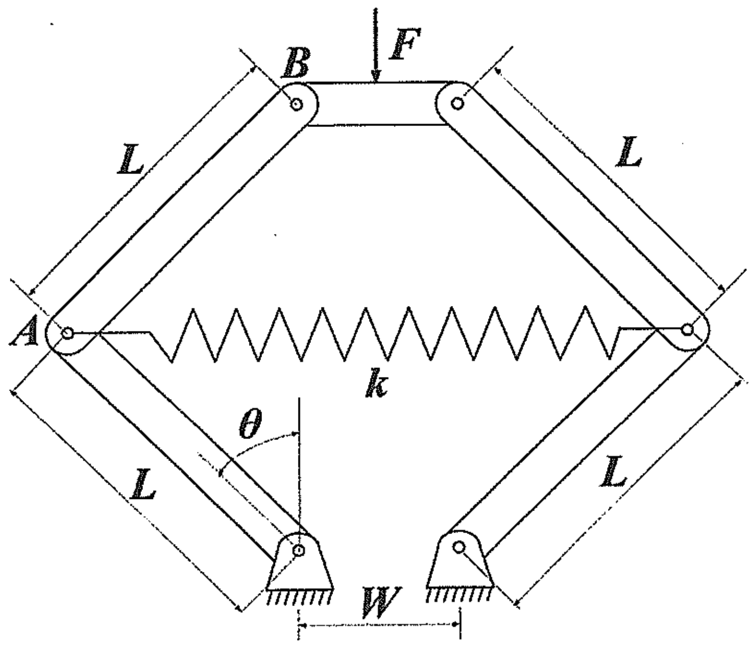

Figure 1 A scale mechanism

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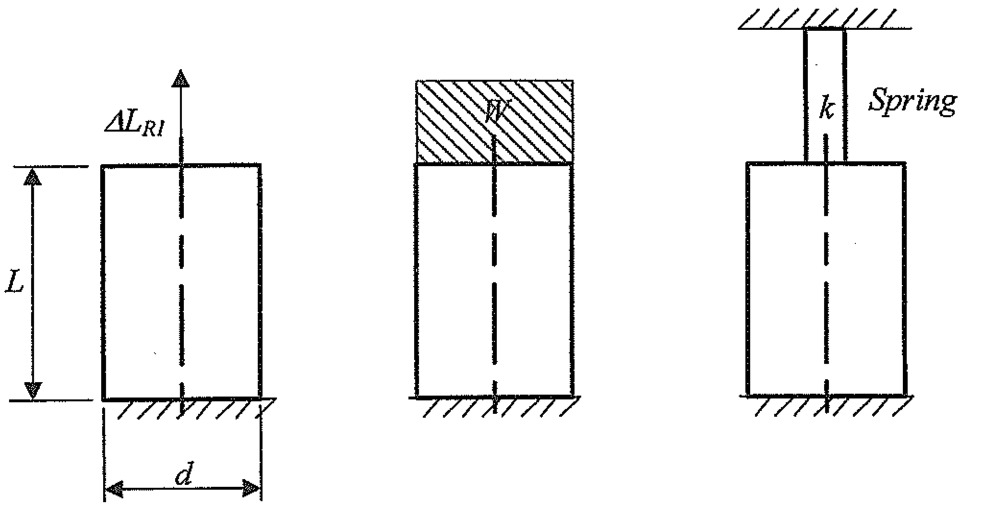
2. One metallic rod R_1 has a size of $\varnothing d \times L$ and the Young's Modulus of E_{R1}. And its thermal expansion factors is α_{R1}, as shown in Figure 2.



(a) Single Rod　　(b) Against a weight　　(c) Against a spring

Figure 2 Three working situations of thermal expanded rod

When the temperature rises from T_o to T，please derive the following parameters with the above-mentioned known parameters

(a) The maximum expansion deflections $\Delta l_{R1,max}$, its maximum working force $F_{R1,\,max}$, and its spring constant k_{R1} of the single rod R_1, as shown in Figure 2(a). (10 分)

(b) When the rod R_1 works against a weight of W, how large is the thermal expanded length Δl_{R1} of the Rod R_1? as shown in Figure 2(b). (10 分)

(c) When the rod R_1 works against a spring with a spring constant of k, how large is the thermal expanded length Δl_{R1} of the Rod R_1? as shown in Figure 2(c). (10 分)

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3. Figure 3-1 below shows a pole supporting a traffic light of weight W. Let W = 10 kg, a = 3 meter, b=5 meter, θ=30 degree.

(a) Using Cartesian vectors, determine the resultant forces and moments of the weight of the traffic light about the base of the pole at A. (10 分)

One day these poles are to be replaced and abandoned. We can make the most use of these poles in the redesign of a playground equipment. Please design a playground nest swing as shown in Figure 3-2 using these traffic light poles. A nest swing can usually host 4 kids with 50 kg each. Assume you can use as many poles as you wish and each pole has a safety factor of 1.5 when holding the traffic light. In your design, please determine the following

(b) The overall sketch of your design, including the relative locations of each poles. Use the projection of the swing to the ground as the Cartesian coordinate origin. (5 分)

(c) The resultant forces and moments of the base of each pole. (5 分)

(d) The safety factor of your swing design. (10 分)

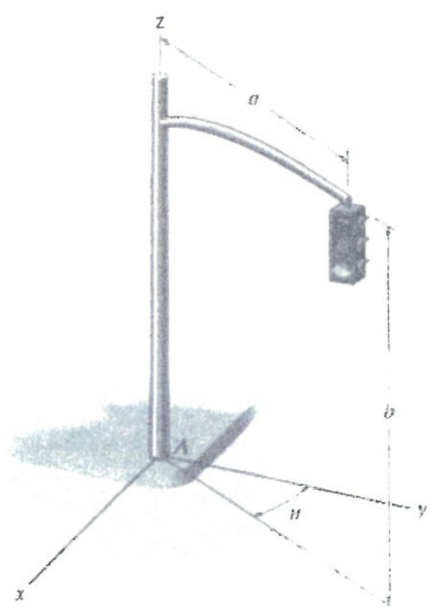

Figure 3-1 Schematics of a traffic light pole

Figure 3-2 A nest swing

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