1. A 68 kg man stands on a 27 kg bar, to which a cable is fixed at point B. The cable passes over two fixed pegs with coefficients of friction as indicated. The contact angles between the rope and pegs are 90°. You many treat the cable the same as you would treat a flat belt. Assume the normal force exerted by the man on the bar acts downward through point A.
(a) Draw the free-body diagram of the man. (3%)
(b) Draw the free-body diagram of the bar. (3%)
(c) Find the smallest force the man can exert on the cable if the bar is to remain horizontal. (14%)

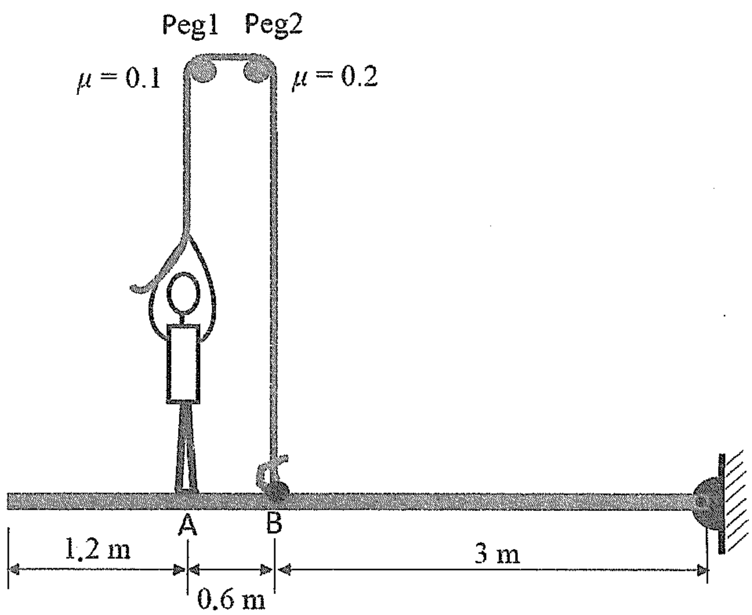

Figure 1

2. A piezoelectric element R_1 has a size of Ø d × L and the Young's Modulus of E_{R1}. And it can be activated to elongate a free deflection of ΔL_{R1f}, as shown in Fig2.

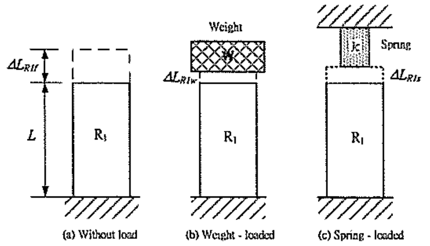

Figure 2: Three working situations of the piezoelectric element.

When the piezoelement R_1 is activated to elongate，please derive the following parameters with the above-mentioned known parameters

(a) Without loading, its maximum working force $F_{R1,max}$ and its spring constant k_{R1} of the piezoelement R_1, as shown in Fig2(a). (3%)

(b) When the piezoelement R_1 works against a weight of W, how large is its weight-loaded deflection Δl_{R1w} of the piezoelement R_1? as shown in Fig2(b). (5%)

(c) When the piezoelement R_1 works against a spring with a spring constant of k, how large is its spring-loaded deflection Δl_{R1s} of the piezoelement R_1 ? as shown in Fig2(c). (5%)

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3. Consider the work of a force (F) being defined by its movements dr. When dr is an imaginary displacement of a body in static equilibrium, the imposed displacement results in a virtual work.

(a) Please write down and proof the conditions for stable equilibrium for systems with one degree of freedom. (20% total, 5% for the conditions, 15% for proof of the conditions)

(b) Figure 3 shows a W(kg) hemisphere supports a cylinder having a specific weight of ρ kg/m^3. If the radii of the cylinder and the hemisphere are both r, please determine the height h of the cylinder which will produce neutral equilibrium in the position shown. (20%)

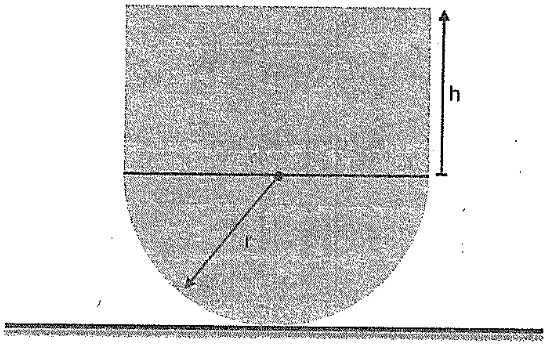

Figure 3

4. A block brake with the hinge location C is shown in Fig. 4. The friction coefficient between lining and drum is μ.

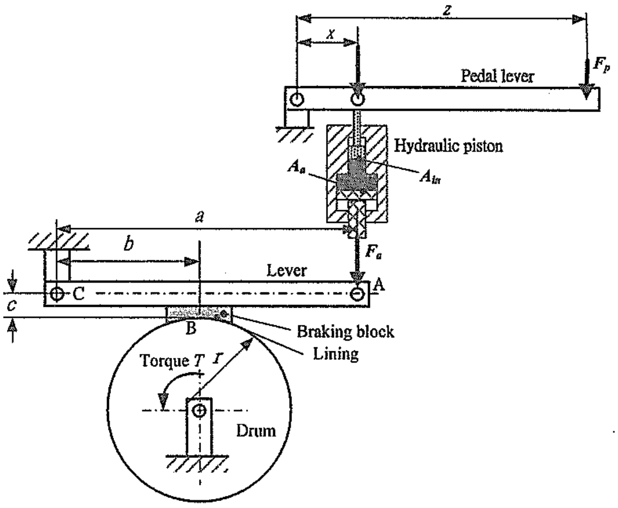

Figure 4 : Block brake

Please derive the following parameters "only" with the above-mentioned dimensional parameters(μ, A_{in}, A_a., a, b, c, r, N, F_a, F_p, z, x)

(a) The acting force F_a induced by the pedal force F_p through the pedal lever and the hydraulic piston with different piston area A_{in} and A_a. (5%)

(b) The free body diagram for the actuating lever with the braking block. (2%)

(c) The normal force N between the lining and the drum (5%)

(d) The horizontal and vertical reaction forces, R_h and R_v, at the pin location C (2%)

(e) The braking torque T_b on the drum (3%)

5. An 80 kg man tries to stay on a tree using a rope only. The diameter of the tree is 30 cm. The center of gravity of the man is as indicated. The coefficient of friction between the rope and the tree is the same as that between the feet and the tree. The rope is kept horizontally. Please find the minimum coefficient of friction at which the man can be supported. (10%)

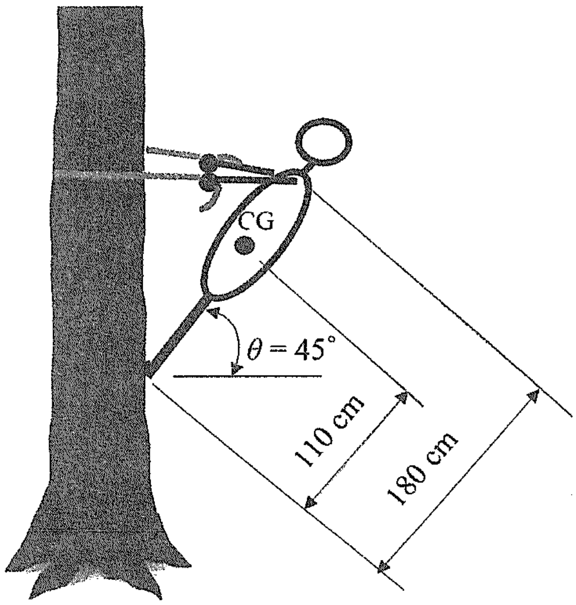

Figure 5