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(1) Two spring strips with different thermal expansion coefficients α_1 and α_2 are firmly welded together as a welded bimetallic strip, as shown in Fig.1. The thermal expansion coefficient α_1 is $1.2\times\alpha_2$. The both spring strips have the same length L, thickness H, and width W, and they have also the same Young's Modulus E.

(Hint: H and W are significantly smaller than L; therefore it is assumed that the thermal expansion affects only the length L)

(a) Determine the longitudinal stiffness of each "unwelded" spring strip, k_1 and k_2. (4%)

(b) When the temperature increase ΔT,

(b-1)determine the thermal induced longitudinal expansion of each "unwelded" spring strip, Δl_1 and Δl_2. (4%)

(b-2) determine the moment distribution M along the whole length x of the welded bimetallic strip. (8%)

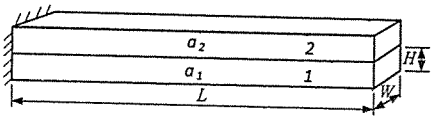

Fig. 1 Welded bimetallic strip

(2) A block brake with the hinge location C is shown in Fig.2. A pneumatic actuator with the piston diameter D and rod diameter d is driven by air pressures of P_1 and P_2 to generate the actuating force F_a at the end of the actuating lever. However there is also a friction force F_f between the piston and the cylinder tube against their relative motion. The friction coefficient between the brake lining and the drum is μ.

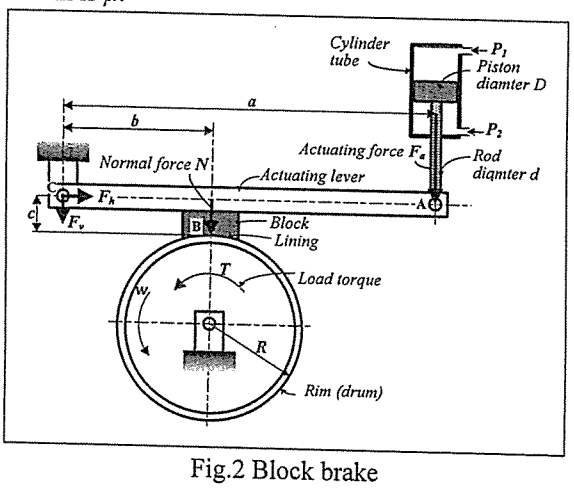

Fig.2 Block brake

Please derive the following parameters with the above-mentioned dimensional parameters.

(a) The actuating force F_a of the pneumatic actuator, (4%)

(b) The normal force N between the lining and the drum, (4%)

(c) The horizontal and vertical reaction forces, F_h and F_v, on the pin location C, (4%)

(d) The braking torque T_b on the drum, (4%)

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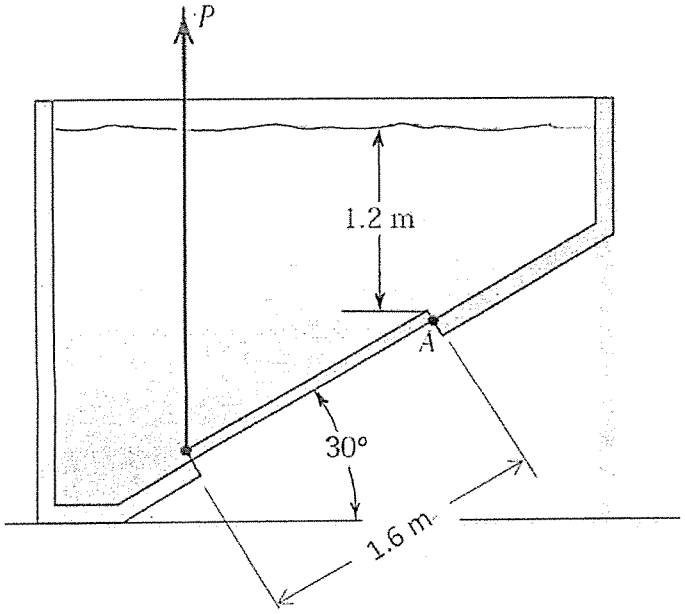
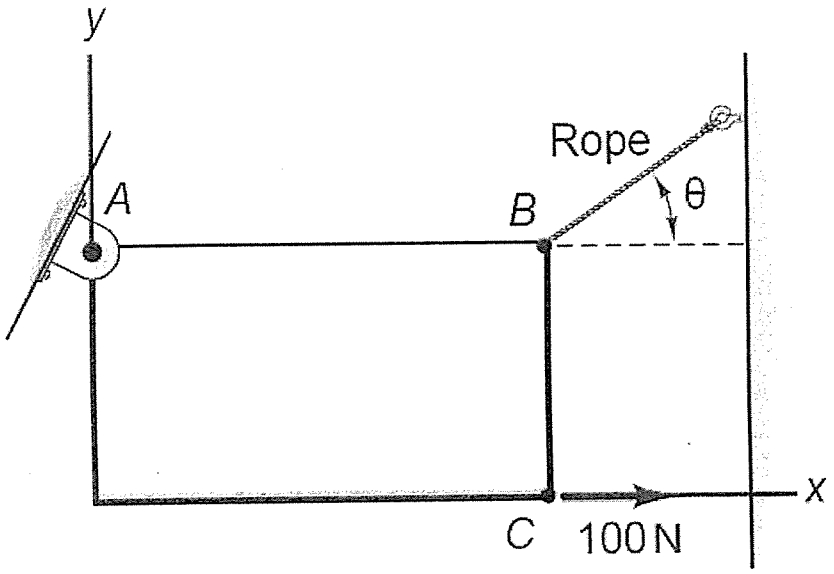
(3). The cross section of a fresh water tank with a slanted bottom is shown. A rectangular door 1.6 x 0.8 m in the bottom of the tank is hinged at A and is opened against the pressure of the water by the cable under a tension P as shown. The specific weight of fresh water is 1000 kg/m^3. Calculate P. (10%)



(4). A 300-N weight of block is held in place by a pin at A and a rope at B. The block is 2 m by 1 m and its center of gravity is located at its geometric center. A 100-N horizontal force is applied at point C. Discuss the solution for the cases: (a) θ is not specified, (b) θ = 0°, and (c) θ = 30°. (10%)



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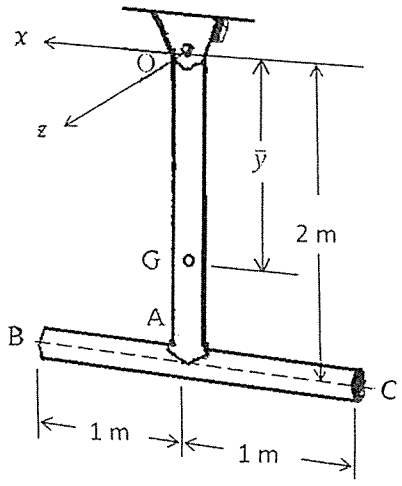
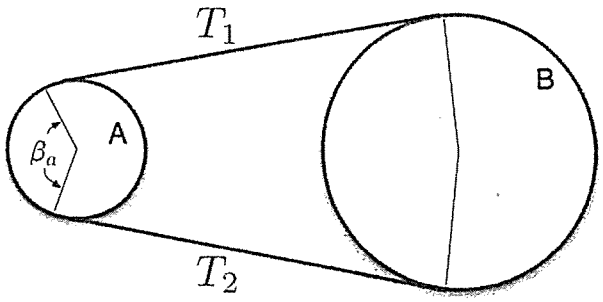
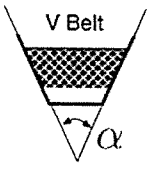
(5). A pendulum consists of two thin rods each having a weight of 10 N. Determine the pendulum's mass moment of inertia about an axis parallel to z-axis and passing through (a) the pin at O, and (b) the mass center G of the pendulum. (10%)



(6) Consider the belt drive as shown in figure. Pulley B drives pulley A clockwise. The radius for pulleys A and B are R_A and R_B, respectively. The coefficient of friction between the belt and the pulley is μ.





(a) Please derive the relationships between T1 and T2 for flat belt. (8%)

(b) Please derive the relationships between T1 and T2 for v-belt. (10%)

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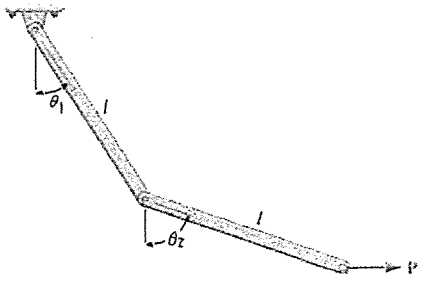
(7) Figure shows a simplified diagram of a robot arm in vehicle assembly plants. Consider a manufacturing task which results in a horizontal force P as shown. Please determine the angles θ_1 and θ_2 for equilibrium of the two links. Assume each link is uniform with a mass *m*. (20%)



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