1. Please calculate the x and y coordinates of the centroid of a semi-cylindrical thin shell (Fig.1) . (9 %)
2. The semi-cylindrical thin shell of mass m and radius r is rolled through an angle θ by the horizontal force P applied to its rim (Fig.2). If the coefficient of friction is 0.20, calculate the angle θ at which the shell slips on the horizontal surface as P is gradually increased. (9 %)
3. A hawser thrown from a ship to a pier is wrapped two full turns around a bollard. The tension in the hawser is 7500 N; by exerting a force of 150 N on its free end, a dockworker can just keep the hawser from slipping. (a) Determine the coefficient of friction between the hawser and the bollard. (b) Determine the tension in the hawser that could be resisted by the 150-N force if the hawser were wrapped three full turns around the bollard. (c) If the dockworker can only exert a force 50 N, at least how many full turns of the hawser should be wrapped around the bollard to resist the same tension in (b)? [Hint: $\ln\frac{T_2}{T_1}=\mu_s\beta$. The tension at the two ends of the hawser are T_1 and T_2. The angle between the two end points of the wrapped part along the hawser is β. The static friction coefficient between the hawser and bollard is μ_s.] (15 %)

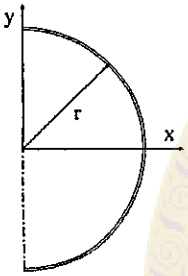

Fig. 1

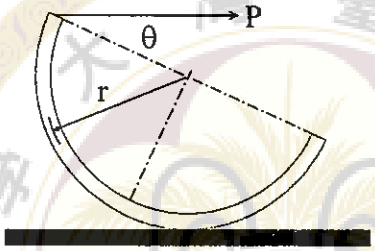

Fig.2

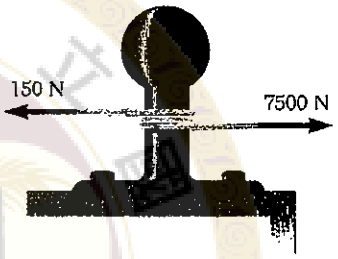

Fig. 3

4. Through turning and tightening the screw nut, the two spring elements A and B are preloaded by a force of F_p, as shown in the following Fig.4(a). They possess the spring rates of C_A and C_B respectively. The element A is a tube with outside diameter D, length L and thickness t, and its Young's modulus is E_A. The element B is an extension spring. Under the preloaded state, the rod is pulled by a force of F_L, as shown in the following Fig.4(b).
   Please derive the following parameters with the above-mentioned dimensional parameters
   (a) The spring rate C_A (5%)
   (b) The deflections, Δl_A and Δl_B, of the elements A and B under the preloaded state (5%)
   (c) The forces F_A and F_B of the two elements A and B under the pulling state (7%)

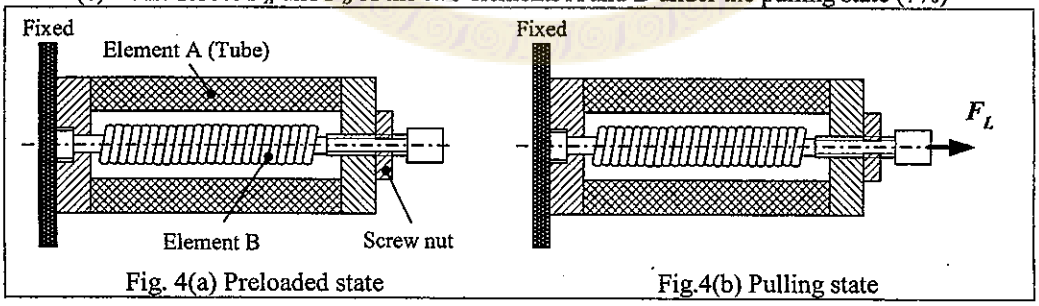

Fig. 4(a) Preloaded state　　Fig.4(b) Pulling state

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5. A block brake with the hinge location C is shown in Fig.5. The friction coefficient between lining and drum is μ.

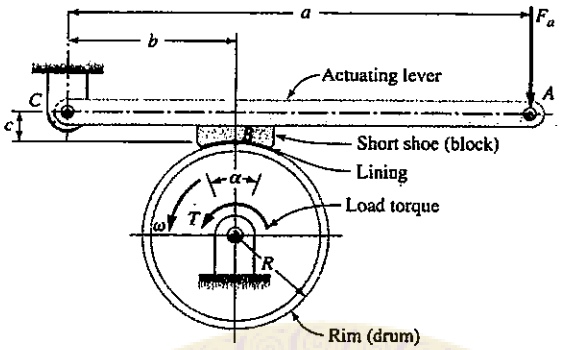

Fig.5 Block brake

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

(a) The normal force N between the lining and the drum (6%)

(b) The horizontal and vertical reaction forces, R_h and R_v, for pin location C (5%)

(c) The braking torque T_b on the drum (5%)

6. For the plane truss with all pin joints shown in Fig. 6, find the forces in members EF and JF. (17 %)

7. A device, as shown in Fig.7, imprints an image at D on metal stock. If a force F of 100 N is exerted by the operator, find the force at D on the stock. Lengths of AB and BC are each 150 mm. (17%)

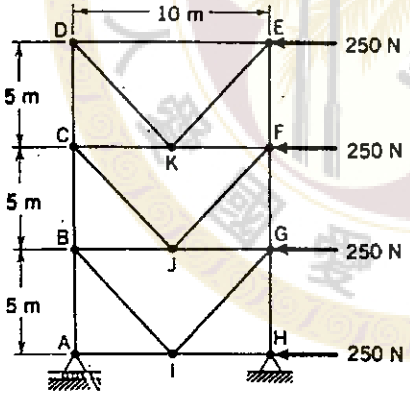

Fig. 6

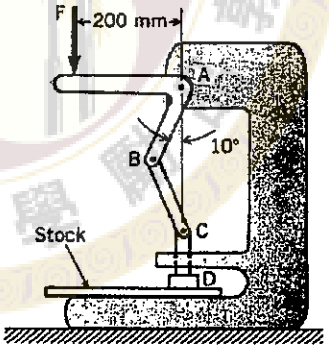

Fig. 7

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