1. (20%) Two blocks M1 and M2 are connected by a rope-pulley system as shown in Fig. 1. M1 is 18 kg while M2 is 40 kg. The coefficient of kinetic friction between M2 and the ground is 0.3. At the time t = 0 s as shown in the figure, the speed of M2 is 0.2 m/s to the right.
(a) (5%) Determine the velocity of M1 when t = 0.
(b) (15%) How far does M1 travel from t = 0 s to 3 s?

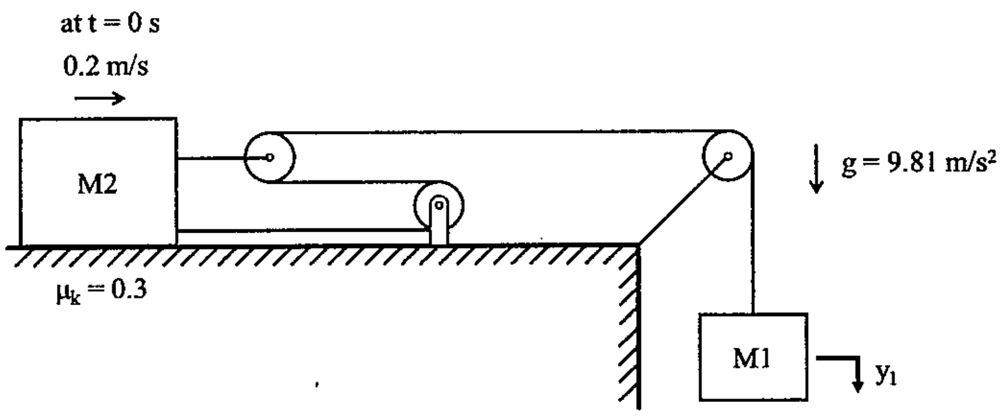

Fig. 1

2. (15%) As shown in Fig. 2, a small sphere of mass 5 kg is carried by the parallelogram linkage. Each link bar has a length of 400 mm and is considered weightless. A spring that has a relaxed length of 450 mm is attached to the linkage as shown in the figure. The linkage is initially stopped at the angle $\theta = 179.9°$ and then released to oscillate. Find the velocity of the sphere when θ gets to 90°.

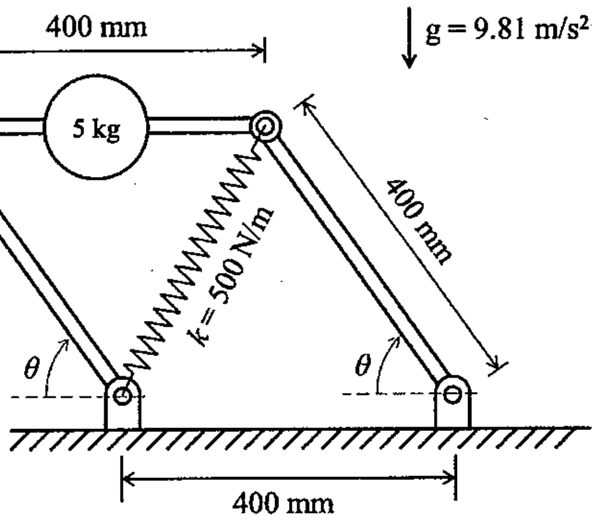

Fig. 2

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3. As shown in Fig. 3 below, a link with length L, mass m, and center of mass at distal end. Springs with stiffness K_a and K_b connect the link at points A and B, respectively. Please determine
(a) torque produced by gravity about point O, (10%)
(b) torque produced by spring forces about point O, (10%).
(c) condition for gravitation torque is completely balanced if $K_a = K_b = K$. (10%)

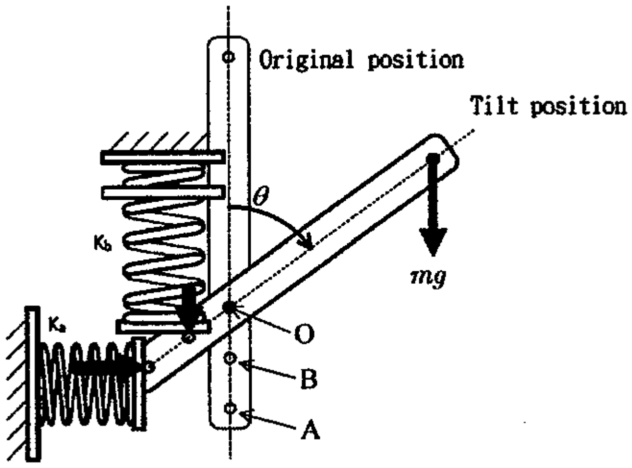

Fig. 3

4. (10%) Fig. 4 shows a circular cam with flat-faced translating follower. If the circular cam with center at C has a radius r (CP=r) and is driven by a motor at axis O. Let the offset distance OC = e. Cam is driven in counter-clockwise (ccw) direction with a constant angular speed ω. How can you analyze the displacement, velocity and acceleration of the follower in terms of the motor angle θ? Write the procedure and necessary equations to solve the kinematic state of the cam mechanism. (No need to solve out the equations)

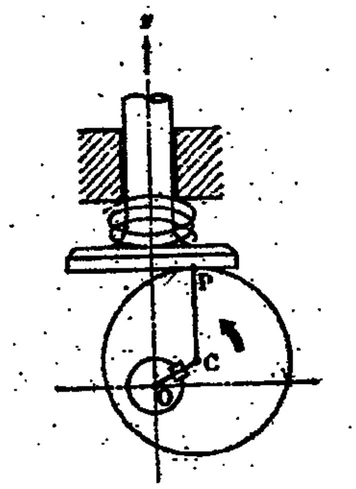

Fig. 4　CP=r, OC = e

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5. (25%) In Fig. 5(a), a rotor having two equal masses M_1 and M_2 lying in different transverse planes C and D is shown. It is evident that the static forces are in balance and also that the dynamic forces F_1 ($=M_1 r\omega^2$ and r, ω are respective the radius and angular speed of the rotor) and F_2 are equal and thus in balance. However, F_1 and F_2 produce an unbalanced couple equal to (a F_1), which will set up reactive forces R_A and R_B at the bearing A and B. Thus, for a balanced system, not only static forces are balanced but the dynamic forces must be balanced. To achieve dynamic equilibrium, one may erect two equilibrium equations, namely, force and moment equilibrium equations as:

$$\sum F_i = 0$$

where F_i's are the dynamic forces of the system, and

$$\sum l_i \times F_i = 0$$

where l_i is the distance from the acting point of force F_i to the point taken for moment.

Now, consider a system shown in Fig. 5(b) having two weights on a rotating shaft.

W_1=66.7 N @ θ=30° (viewed from left end) with a radius r=101.6 mm; W_2=89 N @ θ=270° with a radius r=152.4 mm. The balance weight to be placed in plane 3, W_3, weighs 66.7 N and in plane 4, W_4, weighs 133.4 N. (Neglect gravity)

(a)(5%) Write the force equilibrium equation for the system.

(b)(5%) Write the moment equilibrium equations needed for the system.

(c)(15%) Solve the equations in (a) and (b), then determine the radii and angles of the balance weights viewed from left end, W_3 and W_4, needed to dynamically balance the system.

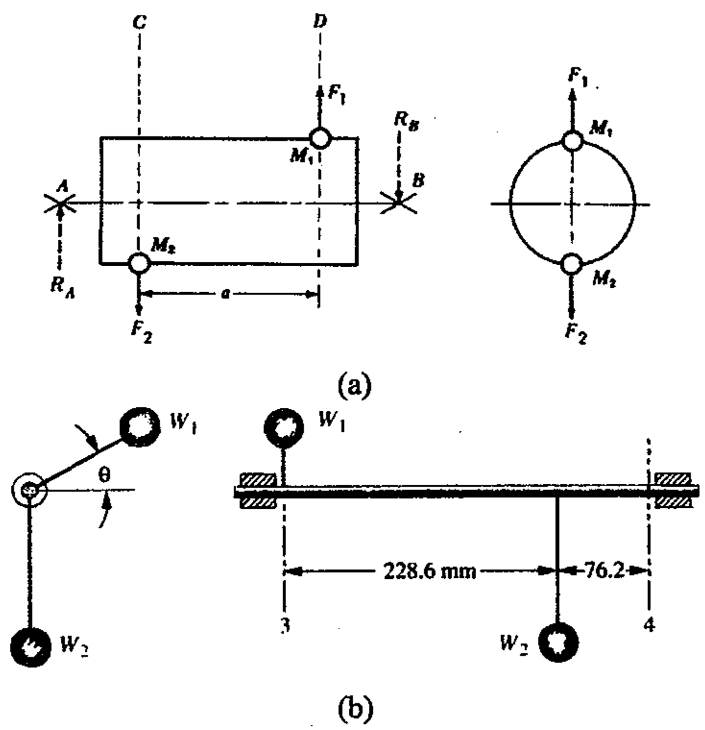

Fig. 5

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