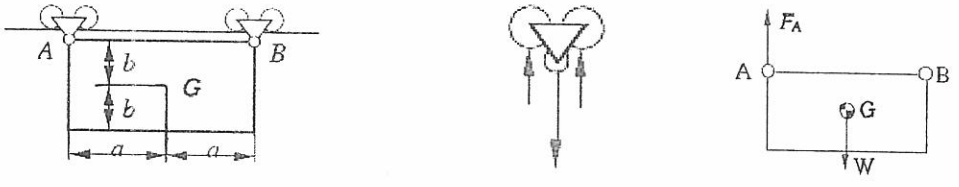
The solutions and answers may be in either Chinese or English.

1. Describe and explain the followings: (20%)
   a. Degrees of freedom in a mechanical system (3%)
   b. Body force and constraint force (5%)
   c. State of equilibrium and state of stability (6%)
   d. Principle of angular impulse and momentum (6%)

2. Explain the Coriolis acceleration in a rotating reference frame. Give two different examples that have Coriolis acceleration in the system and explain your reason. (15%)

3. A uniform rectangular plate is hung from a rail by means of two roller bundles as shown in Fig 1a. The plate is connected to the roller bundle by means of frictionless hinge joints at A and at B. At time t=0 the pin of joint B breaks, allowing the plate to swing downward. Assume that the rollers which support point A are frictionless and that they remain in contact with the rail as shown in Fig.1b. Also assume that the angular displacement from the initial position is small. The moment of inertia of a uniform rectangular plate with sides $2a$ and $2b$ about an axis normal to its plane passing through its centroid is $m[(2a)^2+(2b)^2]/12$, where m is the mass of the plate. Fig. 1c shows the free body diagram of the plate and W=mg. (20%)
   a. Write the equations of motion of the plate as it starts to move. (10%)
   b. Find the initial angular acceleration of the plate as it starts to move. (5%)
   c. Find the initial acceleration of point A. (5%)



(a) (b) (c)

Figure 1

4. A centrifugal clutch, as shown in Fig. 2, consists of a rotating spider *A* which carries four plungers *B*, and an outer rim of wheel *C*. As the spider rotates about its center with a speed, the plungers will move outward and bear against the interior surface of the rim of wheel. The wheel and the spider are independent except for the frictional contact. Each plunger has a mass of 2 kg with a center of mass at *G*, and the coefficient of kinetic friction between the plunger and the wheel is 0.40 and the coefficient of static friction between the plunger and the wheel is 0.9. Determine the possible maximum moment which can be transmitted to the wheel *C* from the spider *A* for a spider speed of 3000 rpm, (1) when the wheel *C* is held stationary, and (2) when the wheel *C* is free to rotate. (15%)

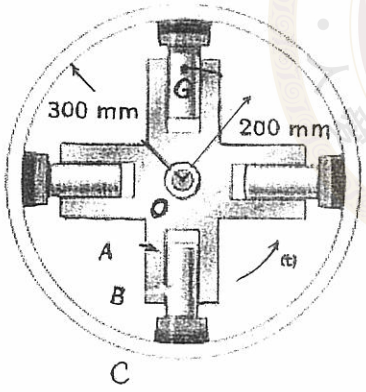


Fig. 2

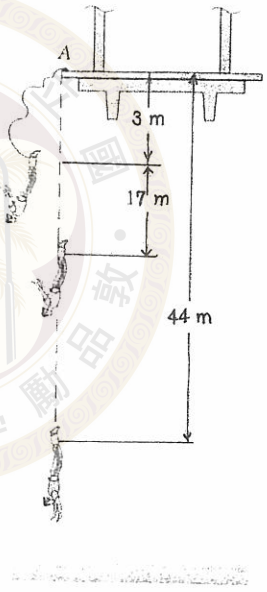


Fig. 3

5. The bungee jumper, an 80-kg man, falls from the bridge at *A* with the bungee cord secured to his angles, as shown in Fig. 3. He falls 20 m before the 17-m length of elastic cord begins to stretch. The 3 m of rope above the elastic cord has no appreciable stretch. The man is observed to drop a total of 44 m before being projected upward. Neglect any energy loss and calculate (a) the stiffness k of the bungee cord (increase in tension per meter of elongation), (b) the maximum velocity v_{max} of the man during his fall, and (c) his maximum acceleration a_{max}. Treat the man as a particle at the end of the bungee cord. (15%)

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6. A spherical pendulum is constructed by a particle of mass *m* suspended by a wire, as shown in Fig. 4. Assume that the mass of the wire is neglected and its length is a function of time as following:

$r = a + b \cos \omega t \ (a > b > 0)$,

where t denotes the time and a, b, and ω are constants.

Please formulate the equation of motion of the system by using a set of spherical coordinates: θ and φ, where θ is measured from the upward vertical and angle φ is measured between a vertical reference plane passing through the support point O and the vertical plane containing the pendulum, as shown in Fig. 4. Gravity is expressed by g. Note that the mechanical system has two degrees of freedom. (15%)

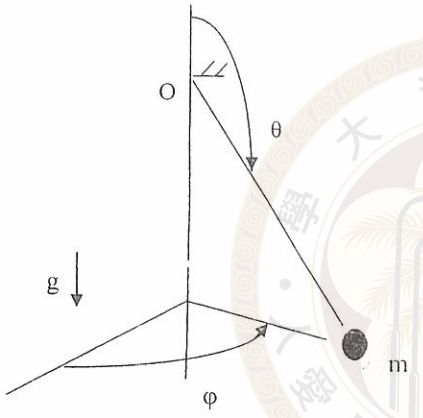

Fig. 4