

- (20 %) A cone of semivertex angle β rolls without slipping on a plane floor (Fig. 1). Let Ω be the constant precession rate of the cone about a vertical axis through its vertex O . Find the velocity and acceleration of a point P on the circumference of its base in terms of r, Ω, β, ϕ .
- (20 %) For a subject a late stance (Fig. 2) during push-off of level walking the following accelerations were recorded: $a_x = 3.25 \text{ m/s}^2$, $a_y = 1.78 \text{ m/s}^2$, and $\alpha = -45.35 \text{ rad/s}^2$. The mass of the foot is 1.12 Kg and the moment of inertia is 0.01 Kg.m^2 . The ground reaction force data from force plate are $F_x = 160.25 \text{ N}$, $F_y = 765.96 \text{ N}$. Calculate the muscle moments (M_a) and reaction forces (F_{ax}, F_{ay}) at the ankle joint during dynamic stance.
- (10 %) Explain (a) Holonomic constraints (b) Nonholonomic constraints (c) What's difference between inverse dynamic and direct dynamic analyses?

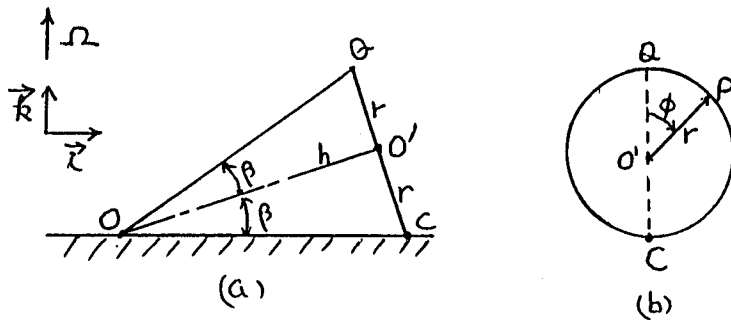


Fig 1. A rolling cone (a) side view (b) View of base.

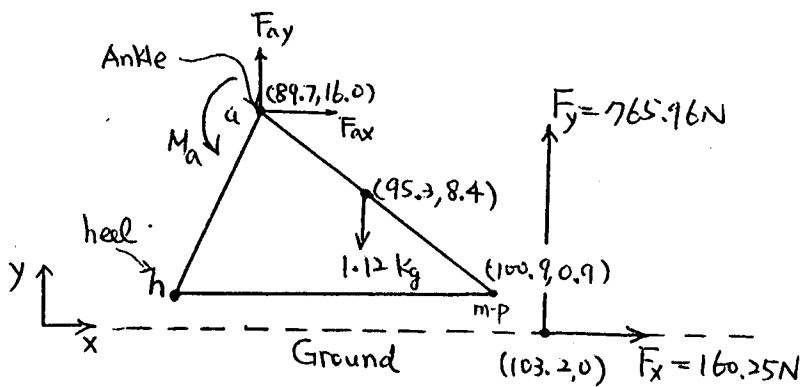


Fig 2.

4. (20%) A light ladder shown in Fig.4 rests on a rough floor and leans against a smooth wall. Rollers are installed at the base of the ladder, A and B, such that the ladder can roll along the x-direction without friction. A weight of 100 lb is hung on the ladder as shown. What is the minimum coefficient of friction between the roller and floor which prevents the base of the ladder from sliding in the y-direction?

5. (20%) Determine the components of the reactions at A and B, (a) if the 500-N load is applied as shown in Fig.5, (b) if the 500-N load is moved along its line of action and is applied at point F (Fig.5).

6. (10%) Uniform bars AB and AC shown in Fig.6, each of weight W and length L , are connected by a smooth pin at A. Bar AB is attached to a frictionless pin at B, while bar AC is pinned to a light frictionless roller at C. The system is in equilibrium when a horizontal force P is applied at C. Find the angle θ by the method of virtual work.

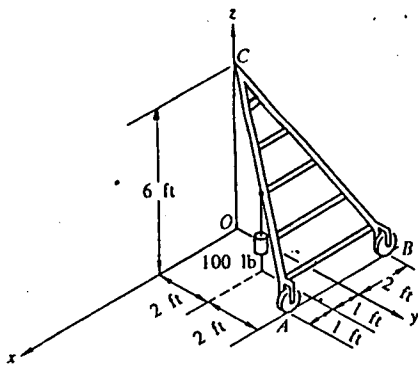


Fig.4

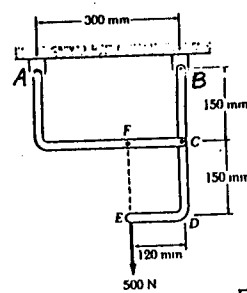


Fig.5

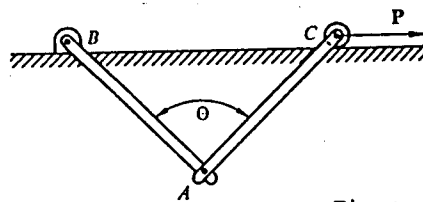


Fig.6