1. The collar has a mass of 2 kg and travels along the smooth horizontal rod defined by the equiangular spiral \( r = e^\theta \) (see Fig 1), where \( \theta \) is in radians and the gravity is neglected. If the tangential force \( F \) maintains a constant angular motion \( \dot{\theta} = 2 \text{ rad/s} \), determine the tangential force \( F \) and the normal force \( N \) acting on the collar when
   (a) \( \theta = 45^\circ \)  
   (b) \( \theta = 90^\circ \)  

2. The roller-coaster car has a mass of 800 kg including its passenger and starts from the top of the hill \( A \) with a speed \( v_A \) (see Fig 2). Neglect friction, the mass of the wheels, and the size of the car. Determine the minimum height \( h \) of the hill so that the car travels around both inside loops without leaving the track. What is the normal reaction on the car when the car is at \( B \) and at \( C \)?
   (a) For \( v_A = 3 \text{ m/s} \)  
   (b) For \( v_A = 0 \)  

3. The chain has a total length \( L < d \) and a mass per unit length of \( m' \) (see Fig 3). If a portion \( h \) of the chain is suspended over the table and released, determine the velocity of its end \( A \) as a function of its position \( y \). Neglect friction.
4. The circular concrete culvert rolls with an angular velocity of $\omega = 0.5 \text{ rad/s}$ when the man is at the position shown (see Fig. 4). At this instant the center of gravity of the culvert and the man is located at point G, and the radius of gyration about G is $k_g = 3.5 \text{ ft}$. Determine the angular acceleration of the culvert. The combined weight of the culvert and the man is 500 lb. Assume that the culvert rolls without slipping, and the man does not move within the culvert. (20%)

Fig. 4

5. The two tugboats each exert a constant force $\mathbf{F}$ on the ship (see Fig. 5). These forces are always directed perpendicular to the ship’s centerline. If the ship has a mass $m$ and a radius of gyration about its center of mass $G$ of $k_m$, determine the angular velocity of the ship after it turns 90°. The ship is originally at rest. (10%)

Fig. 5

6. A 2-kg mass of putty $D$ strikes the uniform 10-kg plank $ABC$ with a velocity of 10 m/s. If the putty remains attached to the plank (see Fig. 6), determine the maximum angle of $\theta$ swing before the plank momentarily stops. Neglect the size of the putty. (20%)

Fig. 6.