P.1 (25%) Explain following terms:

(a) D'Alembert's principle

(b) radius of gyration

(c) principle of virtual work

(d) conservative mechanical system

(e) Coriolis acceleration

P.2 (30%) In a study of head injury against the instrument panel of a car during sudden or crash stops where lap belts without shoulder straps are used, the mechanical model shown in Figure 1 is analyzed. The hip joint O is assumed to remain fixed relative to the car, and the torso above the hip is treated as a rigid body of mass m freely pivoted at O. The center of mass of the torso is at G with the initial position of OG taken as vertical. The radius of gyration of the torso about O is k_o. If the car is brought to a sudden stop with a constant deceleration a, determine the velocity v relative to the car with which the model's head strikes the instrument panel. If the panel has a Young's modulus of E, determine the maximum deformation (δ) of the panel at the contact point and the largest impact force F. Substitute the values m=50kg, $\bar{r}$=450mm, r=800mm, k_o=550mm, θ=45 deg, a=10g and E=1720MPa and compute v, δ and F.

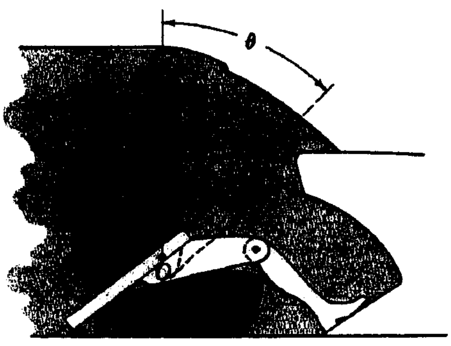

Figure 1.

P.3 (25%) The ~~small~~ car shown in Figure 2 which has a mass of 100kg rolls on the horizontal track with a constant speed v=0.6m/s and it carries the girl who is seated on the chair mounted on the rotating rod with r = 4m. A geared motor drive maintains a constant angular speed $\dot{\theta}$= 4 rad/s of the rod. The girl has a body mass of 12kg. Determine the reactive force acted on the girl's back by the seat.

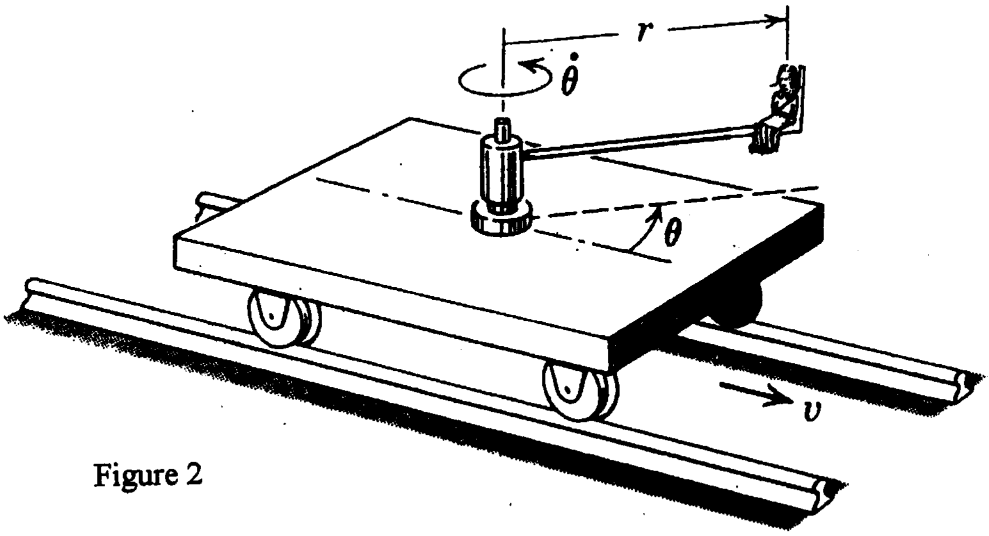

Figure 2

P. 4 (20%) The cam (Figure 3) has a shape such that the center of the roller A which follows the contour moves on a curve defined by $r = b - c\cos\theta$, where $b > c$. If the cam does not rotate, determine the magnitude of the total acceleration of A in terms of θ if the slotted arm revolves with a constant counterclockwise angular rate $\dot{\theta} = \omega$.

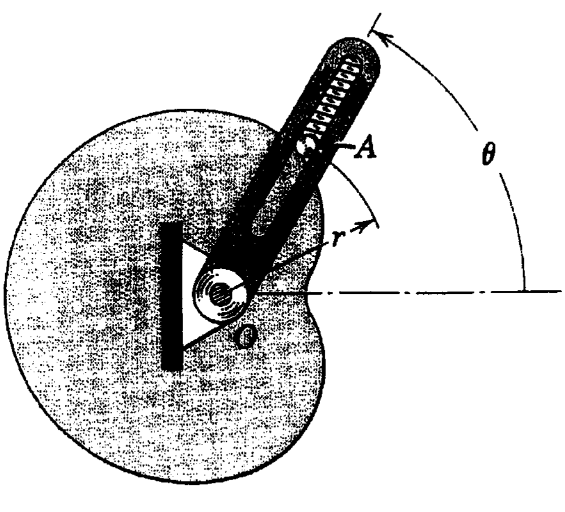

Figure 3.