

Name \_\_\_\_\_ Social Security Number \_\_\_\_\_

*Instructions: Please write very neatly, show your work, and box in your answers. Also remember to indicate the units in your answers. Good luck.*

**THEORY PROBLEM**

- (a) (10 points) Draw a figure showing  $r, \theta, x, y, \mathbf{i}, \mathbf{j}, \mathbf{n}_r,$  and  $\mathbf{n}_\theta$ .
- (b) (10 points) Given  $\mathbf{n}_r = \cos(\theta)\mathbf{i} + \sin(\theta)\mathbf{j}$ , and  $\mathbf{n}_\theta = -\sin(\theta)\mathbf{i} + \cos(\theta)\mathbf{j}$ , show that

$$\dot{\mathbf{n}}_r = \dot{\theta}\mathbf{n}_\theta, \text{ and } \dot{\mathbf{n}}_\theta = -\dot{\theta}\mathbf{n}_r.$$

- (c) (10 points) Show that  $\mathbf{v} = v_r\mathbf{n}_r + v_\theta\mathbf{n}_\theta$  and  $\mathbf{a} = a_r\mathbf{n}_r + a_\theta\mathbf{n}_\theta$  in which

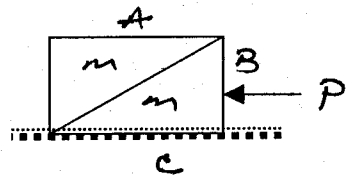
$$v_r = \dot{r}, v_\theta = r\dot{\theta}, a_r = \ddot{r} - r\dot{\theta}^2, a_\theta = r\ddot{\theta} + 2\dot{r}\dot{\theta}.$$

**HOMEWORK PROBLEM**

- (a) (10 points) Carefully, draw free body diagrams of the blocks shown. Assume that  $P$  is the largest force before which block  $A$  slides up on  $B$ . The static coefficient of friction is  $\mu_s$  and there is no friction between block  $B$  and surface  $C$ .

- (b) (10 points) Sum forces in the horizontal and vertical directions to get 4 equations in terms of the unknowns  $N_{AB}, N_{BC}, a,$  and  $P$  and the known parameters  $m, g, \theta,$  and  $\mu_s$ .

- (c) (10 points) Solve for  $P$  and  $a$  (acceleration); that is express each in terms of the known parameters.



**NEW PROBLEM**

- (a) (10 points) A ski-lift of mass 100 kg coasts for a short time on the wavy rail shown (see below the top view of the ski-lift and the rail). Neglecting friction between the ski-lift and the rail, draw a *complete* free body diagram of the ski-lift (horizontal plane and vertical direction, too).

- (b) (10 points) If the ski-lift moves at the speed of 2 m/s at point  $A$ , determine the radius of curvature  $\rho$  of the ski-lift at point  $A$  and then at point  $B$ .

- (c) (10 points) Calculate the normal force vector  $\mathbf{N} = N_x\mathbf{i} + N_y\mathbf{j}$  exerted on the ski-lift by the rail at point  $A$  and then at point  $B$ .

Potentially helpful expressions

$$\sin(60) = \sqrt{3}/2 = 0.866,$$

$$\cos(60) = 1/2 = 0.5,$$

$$\tan(60) = \sqrt{3} = 1.732,$$

$$\rho = \frac{[1 + (dy/dx)^2]^{3/2}}{d^2y/dx^2}$$

