

Due: Nov. 19

**1. Rotation and Translation.**

An automobile has horizontal acceleration  $a$  and instantaneous velocity  $v$ , and its tires have radius  $r$ . Assume that they are rolling without slipping. Determine what point on a tire has maximum acceleration with respect to the ground, and what its value is.

**2. is down, down?**

[Assume the earth is perfectly spherical] Because of centrifugal acceleration due to the rotation of the earth, the direction in which a plumb line hangs is not directly toward the center, but deviates from this direction by an angle  $\varepsilon$ .

(a) If  $g_0$  is the true acceleration due to gravity, show that at latitude  $\lambda$ ,

$$\tan \varepsilon = \frac{R\omega^2 \sin \lambda \cos \lambda}{g_0 - R\omega^2 \cos^2 \lambda}.$$

( $R$  is the earth's radius and  $\omega$  its angular velocity of course)

(a) At what latitude is the deviation greatest? What is the angle  $\varepsilon$  at that point?

**3. spinning bucket.**

A bucket of water of radius  $R$  is rotating steadily about its symmetry axis with angular velocity  $\omega$ , and the water with it. Find the shape of the surface of the water. [Hint: The force per unit volume in a stationary fluid is given by the gradient of the pressure,  $\mathbf{f} = \nabla p$ .]

**4. an artillery problem.**

At a northern latitude  $\lambda$ , a projectile is fired due east with an initial velocity  $v_0$ , and an angle  $\beta$  up from the horizontal.

(a) Show that the net sideways deflection of the projectile when it hits ground is

$$d = \frac{4v_0^2}{g^2} (\omega \sin \lambda)(\sin^2 \beta \cos \beta).$$

(b) If your muzzle velocity is 300 m/s and you fire at an angle  $\beta = 45^\circ$  at latitude  $50^\circ$ , what will be the net *angular* deflection of your shell?