Chapter 12:

For drawings consult your class notes, based on what the instructor sketched on the blackboard.

A mass of 100 kg is suspended by ropes as shown in the sketch done on the board. Rope 1 runs to a vertical wall and rope 2 runs to the ceiling. Rope 1 makes an angle θ_1 with the horizontal and rope 2 makes an angle θ_2 with the horizontal. Suppose that $\theta_2 = 45°$ and $\theta_1 = 20°$. What is the tension in the ropes? Answer: $T_1 = 780$ N, $T_2 = 1037$ N.

A uniform rod of mass M and length L is propped against a very smooth wall and makes an angle θ with the vertical. It stays there. What frictional force is acting at the point where the rod touches the floor, if there is no friction with the wall?

Answer: $f_s = Mg \tan\theta/2$.

An empty box of mass M is being pushed at constant velocity across a level table by a constant horizontal force $\mathbf{F}$ applied at a point a distance h above the table surface. The box has height L and width w in the direction of motion. What is the largest possible value of h such that the box doesn't tip over forward when pushed? If $M = 1$ kg, $w = 0.1$ m and $F = 1$ N, find $h_{\max}$.

Answer: $h_{\rm max} = Mgw/(2F) = 0.5$ m.

The gravitational potential energy of the center of mass of an object, as a function of θ, the angle by which it is tipped away from an axis perpendicular to the surface of the earth, is $U_g(\theta) = -\alpha\theta + \beta\theta^2$. Here α and β are positive constants. At what angle θ_0 is the object in equilibrium, and is it stable or unstable equilibrium?

Answer: $\theta_0 = \alpha/(2\beta)$, and it is a point of stable equilibrium (minimum of U_g).

CHAPTER 11:

Calculate the torque due to a force $\mathbf{F} = \widehat{\mathbf{k}}F$ applied at $\mathbf{r} = (\widehat{\mathbf{i}}a + \widehat{\mathbf{j}}b)$.

Answer: $\vec{\tau} = F(\widehat{\mathbf{i}}b - \widehat{\mathbf{j}}a)$.

A dumb-bell-like object has sliding masses, each of mass m. If the object is spinning about its center of mass with angular speed ω_i, how fast is it spinning when the masses slide to 1/4 of their previous distance from the center of mass?:

Answer: $\omega_f = 16\omega_i$.

On a playground is a merry-go-round that is just a freely rotating disc with rotational inertia I_{cm}. The disc has mass M and radius R. A little boy of mass m_b runs at velocity $\mathbf{v}_0$ tangent to the rim of the disk and grabs on. The disk was originally rotating at angular speed ω_0 but after the little boy jumps on, the system is at rest. What was the original angular speed ω_0 of the disc?

Answer: $\omega_0 = (m_b v_0 R)/I_{\text{cm}}$.