Ph201H/211H
F08 Class Problems – November 20, 2008

For problems 1-4, write down the center of mass equation as applied to the fictitious "point particle" and the conservation of energy equation as applied to the appropriate object.

1. A block slides across a horizontal surface with initial velocity v_{cm} and is brought to rest by the frictional force F_f exerted by the surface. The center of mass of the block moves through a distance s_{cm}.

2. A meter stick initially at rest is free to move on a frictionless horizontal surface. A constant external force is applied at the 25-cm mark. The point of application of the force moves through the distance s as the center of mass of the meter stick moves through the distance s_{cm}.

3. A ball of mass M rolls without slipping down an incline at an angle θ. ("Rolling without slipping" means that there is no slipping or relative movement at the instantaneous point of contact between the ball and the incline.) The ball starts from rest; its center of mass moves a distance s_{cm} along the incline. At the bottom of the incline the ball has acquired a center of mass velocity v_{cm}.

How would the CM and COE equations change if there were slipping at the point of contact?

4. An athlete crouches and jumps vertically upward by straightening her legs. Assume that in the process she pushes down on the floor with a constant force F in addition to her weight. At the instant her foot leaves the ground, her center of mass has risen by s_{cm} and she has acquired a vertical velocity v_{cm}.

5. A 50-kg ice skater pushes away from a railing, exerting a constant force of 55 N as she does so. Her center of mass moves a distance of 32 cm until she loses contact with the railing. (a) What is the speed of the center of mass of the skater as she breaks away from the railing? (b) What is the change in the stored energy of the skater during this process. Assume there is negligible friction between her skates and the ice.

6. Jim (mass 72 kg) and Joan (mass 50 kg) are skating on ice. Jim is standing with his back against a wall. Joan is facing him; they hold hands with each other with their arms fully bent. Each pushes against the other as they straighten their arms until they lose contact. Jim exerts a constant force of 55 N through a distance of 0.32 m; this is the distance that his hands move as he straightens his arms. At the instant contact is broken, Joan's center of mass has moved through a total distance of 0.58 m as a result of the extension of both pairs of arms. (a) What is Joan's speed just after contact is broken? (b) What is the change in the stored energy of each skater during this process?

7. A 5.2-kg block is projected over a horizontal surface with an initial horizontal velocity of 0.65 m/s before coming to rest. The coefficient of kinetic friction between the block and the surface is 0.12. (a) What is the change in internal energy of the system of block + surface? (b) How far does the center of mass of the block move before coming to rest?