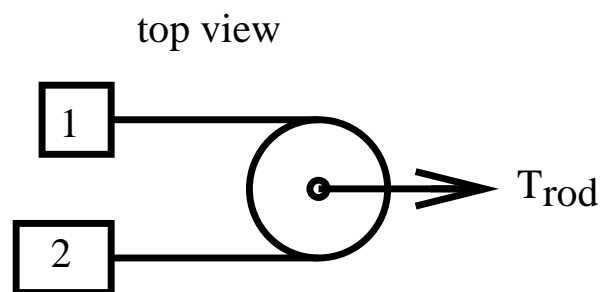


**PROBLEM SET #9**  
**Due Friday 13th November 9am**

**READING:** Young and Freedman, Chapter 8 §§1-5 and Young and Freedman, Chapter 13 §§1-5.

**FORMAT:** Please read the instructions on the web page concerning the required format for problem sets.

- 9-1)** Young and Freedman, exercise 8.107, page 282.
- 9-2)** Young and Freedman, exercise 8.114, page 283.
- 9-3)** When two objects collide the “impact parameter,”  $b$ , is what *would have been* the distance of closest approach of the centers of the objects if they had not deflected each other. Consider billiard balls of radius  $R$  and assume that they collide completely elastically. A head-on collision has impact parameter zero. A glancing collision has impact parameter  $2R$ .
- Two billiard balls, with zero momentum frame velocities of  $+u/2$  and  $-u/2$  in the  $x$ -direction, collide with impact parameter  $b = \sqrt{2}R$ .
- a) At what angle to the  $x$ -axis do the balls exert a force on each other when they collide?
- b) What angle to the  $x$ -axis (in the zero momentum frame) do the balls’ velocities make after colliding.
- c) Consider the same collision in the lab frame, in which one of the balls is initially at rest. What angle does the incoming ball make, after its collision, to its initial direction in this frame?
- 9-4)** Young and Freedman, exercise 13.10, page 448. Please use  $f$  and  $A$  instead of the values given.
- 9-5)** Young and Freedman, exercise 13.17, page 448.
- 9-6)** Two masses  $m_2 > m_1$  slide on a horizontal table with coefficients of static and kinetic friction both equal to  $\mu$ . They are attached to a massless string that loops around a massless pulley. The figure at right shows the view from above. This system is pulled to the right by a massless rod with tension  $T_{rod}$ .



- a) Explain in *words* why a certain minimum tension in the rod is required in order for *both* masses to accelerate. You may want to draw one or two free body diagrams.
- b) What is the minimum tension in the rod such that *both* masses accelerate?
- c) The acceleration of the pulley,  $a_p$  is not in general equal to either of the accelerations of the masses,  $a_1$  and  $a_2$ . How *does* the acceleration of the pulley depend upon the accelerations of the two masses? Explain why your answer makes quantitative sense.