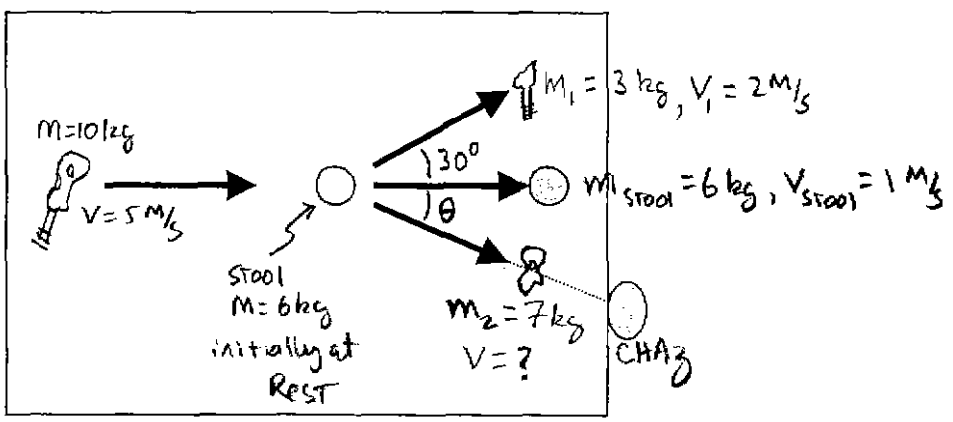
Exam 3 (November 12, 1999)

Please read the problems carefully and answer them in the space provided. Write on the back of the page, if necessary. Show all your work. Partial credit will be given.

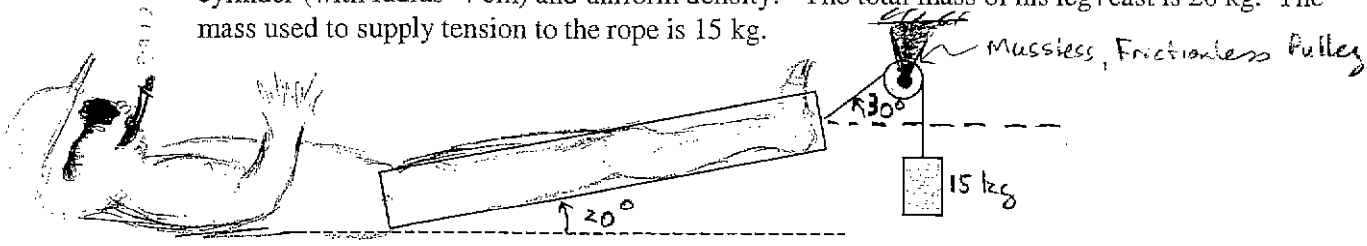
Problem 1 (20 pts):

I have a friend named Chaz. He's not *quite right*, if you know what I mean. Once he went to a punk rock concert by Lulu and the Pierced Navels. He shoved his way up to the stage to gaze at whatever navels he could see when Lulu slid her guitar along the frictionless stage surface toward another band member. Along the way, the guitar struck a piano stool and broke into two pieces. Each guitar piece and the stool slid across the stage as pictured in the diagram below (drawn from above). One piece of the guitar hit Chaz in the head and changed him forever. Using the information in the diagram below, determine the velocity with which the guitar part struck Chaz.



Problem 3 (25 pts):

Chaz was knocked over a railing when he was hit by the guitar. As he fell, his leg was broken in a number of places. He ended up in the hospital in traction. The doctor arranged his leg as shown in the diagram below. Assume Chaz's leg (+cast) can be thought of as a 1 meter long cylinder (with radius=4 cm) and uniform density. The total mass of his leg+cast is 20 kg. The mass used to supply tension to the rope is 15 kg.



a) Where is the center of mass of Chaz's leg + cast (label it on the drawing)?

b) On the figure of Chaz's leg, draw and label the relevant forces, i.e., create a free body diagram of Chaz's leg

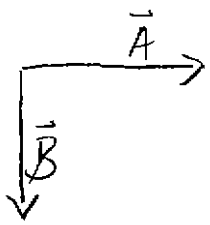
c) Determine the effective mass of Chaz's leg and cast and the net force on Chaz's hip joint.

Problem 4 (15 pts – 3 pts each):
Short answer … be brief and concise.

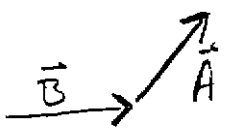
a) Why do tightrope walkers usually carry long poles?

Consider the diagrams below. State the direction of the vector cross product, $\vec{A}x\vec{B}$. Possibilities are left, right, up, down, in paper, out of paper, none (because cross product is zero).

b)



c)



d) Consider a hollow sphere and a solid sphere of the same mass and radius. Which would roll (without slipping) faster down an inclined plane? Why?

d) It used to be common wisdom to build cars to be as rigid as possible to withstand collisions. Today, cars are designed to have "crumple zones" that collapse upon impact. Explain (very briefly) the advantage of such a design using concepts we have covered recently in our class.

Problem 5 (15 pts):

Whoosh! Time flies. You are now in the future .... It turns out you did so well in P113 that you decided to become a mechanical engineer. Now you have a fulfilling job working for the Gyros-are-Us company in Poughkeepsie. Your pinhead boss asks you to work on the design of the company's latest gyroscope. It is pictured below. It is made up of a wheel with moment of inertia, I=0.003 kg-m^2, that spins on an axis (A) that is free to rotate (precess) in the horizontal plane about a pivot (B). The mass of the wheel/axis combination is 0.2 kg. The axis A is 15 cm long. The wheel is mounted at the midpoint of the axis. The precessing end of the axis A is attached to a vertical spring that precesses in a frictionless manner with the end of the axis. The spring has a natural length of x_0 =10 cm and is compressed 2 cm (from its natural length) . The gyroscope wheel spins about axis A with a rate of 100 rad/s. The gyroscope precesses in the horizontal plane at a rate of 0.04 rev/s. What is the spring constant? What is the Normal Force of the Pivot (B) on the Axis A?