2048 H Exam 3

Name:
Problem 1: [28 points]

Two objects, both with mass $m=10$ kg, are connected by a rope and placed on a pulley attached to a triangular stage. The pulley is a uniform circle with mass $M=5$ kg and radius of 0.2 meters. Rope moves without slipping on the pulley and the top surface of the triangular stage is frictionless. Use the moment of inertia, $I = \frac{1}{2}MR^2$, for the pulley.

(a) Are the tensions same for the segment A and B? [3 pts]
(b) Draw the force diagrams for each object and at the pulley (you may only show the relevant forces for the resulting motion) [6 pts]
(c) Find acceleration of the masses and indicate the direction of the motion. [12 pts]
(d) Find tension(s) for the rope [7 pts]
Problem 2 [28 points]

As shown above, a ball is released at height $h$ after which it rolls down without slipping on a looped track. The loop diameter is given by $D$. The mass of the ball is $M$ and the moment of inertia is given by $I = \frac{2}{5} MR^2$.

(a) Find the velocity of the ball at point $A$ at the bottom of the slope [in terms of $h$, $M$, $R$, $D$] [7 pts]
(b) Find the velocity of the ball at point $B$ at the top of the loop [in terms of $h$, $M$, $R$, and $D$] [7 pts]
(c) What is the condition required for the ball to make it past $B$? [6 pts]
(d) Find the minimum height required for the ball to make it past $B$. [8 pts]
Problem 3 [28 points]

Consider a situation of a tether ball game. As drawn in the figure below a ball with mass 1 kg is attached to a rope which is 1 m. The initial velocity of the ball is 5 m/s. The rope gets wrapped to the pole and gradually decreases in length. Neglect gravity and air friction.

(a) What are the conserved quantities for the ball as the rope gets wrapped to the pole? [4 pts]
(b) What is the velocity of the ball when the length of the rope is 0.5 m? [8 pts]
(c) Find out the change in kinetic energy as a function of the rope length l. [8 pts]
(d) Find out the work by the pole as a function of the rope length l. [8 pts]
Problem 4 [16 pts]

A beam with mass $M = 10 \text{ kg}$ supports a mass, $m=1\text{kg}$, $2/3$ of the length outward on its length. The length of the beam is 3 meters. The beam is supported by a pivot point in the wall and a rope with tension $T$.

(a) Draw force diagram for the beam [4 pts]
(b) Calculate tension [6 pts]
(c) Calculate the force on the wall at the pivot point [6 pts]