PROBLEM 1 (25 points). A specially designed parachute suddenly deploys at time $t = 0$, and starts to decelerate a racing car, to which it is attached at the rear. Observers stationed on the side of the racetrack make measurements of the position of the racing car as a function of time $x(t)$. Their data fit the following equation:

$$x(t) = -At^2 + Bt - Ce^{-Dt} \tag{1}$$

with $A = 10.0\ \mathrm{m/s^2}$, $B = 100\,\mathrm{m/s}$, $C = 10.0\ \mathrm{m}$, and $D = 1.00\ \mathrm{s^{-1}}$. (CAVEAT: Do *not* assume that $x(t=0) = x_0 = 0$.)

(a) What is the *instantaneous* velocity of the racing car immediately after the deployment of the parachute at $t = 0$?

(b) What is the *instantaneous* velocity of the racing car after a time $t = 1$ second?

(c) What is the *average* velocity of the racing car in the interval from $t = 0$ to $t = 1$ second?

(d) What is the *instantaneous* acceleration of the racing car immediately after the deployment of the parachute at $t = 0$?

(e) What is the *instantaneous* acceleration of the racing car after a time $t = 1$ second?

(f) What is the *average* acceleration of the racing car in the interval from $t = 0$ to $t = 1$ second?

PROBLEM 2 (10 points). A swimmer can swim at a leisurely, steady speed of 0.500 m/s in still water. She is trying to swim at her usual leisurely, steady speed directly across a 40.0-meter-wide river whose steady current is 0.300 m/s, so that she can arrive at a point directly across the river on the opposite bank.

(a) At what upstream angle must she aim her swimming so that she can arrive at this point?

(b) How long would it take her to reach the other side?

PROBLEM 3 (15 points). An Olympic long jumper makes a jump of a distance 9.00 m. His horizontal speed is measured to be 9.50 m/s, as he leaves the ground at $t = 0$. Assume that air resistance is negligible, and that he leaves the ground, and also lands, standing upright.

(a) At what time does he reach his maximum height?

(b) What is the maximum height he reached?

(c) At what initial angle did he push away from the ground at $t = 0$?

PROBLEM 4 (25 points). Two cube-shaped masses $m_1 = 5.00$ kg and $m_2 = 10.0$ kg are attached to each other by means of a string stretched over a pulley, but these two masses are on opposite sides of the pulley which is rigidly attached to the top of a double incline. The two inclines on the two sides of the pulley have oppositely signed slopes, but the same inclination angle $\theta = 30.0°$ with respect to horizontal; see Figure 1. The pulley is frictionless and massless,

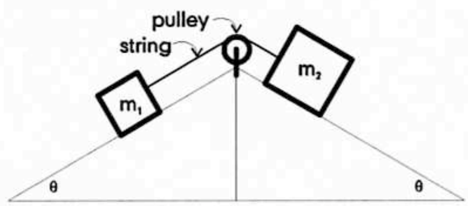

Figure 1: Figure for Problem 4.

and the string is nonelastic and massless; the masses slide frictionlessly on the inclines (i.e., airtracks).

(a) Draw separate free-body diagrams for the two masses. Label all forces acting on the masses.

(b) What is the common magnitude of the acceleration of the two masses?

(c) What is the tension in the string?

PROBLEM 5 (25 points). Two cube-shaped masses m_1 and m_2, with different materials glued onto their undersides, are connected together by a massless, nonelastic string. They are sliding down together an incline at an angle $\theta = 30.0°$ to the horizontal (see Figure 2 below). The coefficients of kinetic friction are $\mu_1 = 0.200$ for the lower mass $m_1 = 5.00$ kg, and $\mu_2 = 0.300$ and for the upper mass $m_2 = 5.00$ kg, respectively.

(a) Draw separate free-body diagrams for the two masses. Label all forces acting on the masses.

(b) If there were no string to connect the two masses, what would be the two accelerations of the two masses, respectively? Now connect the two masses by means of the string. Will the string be in tension, or will it become slack, if the the two masses are released at the same time with the string initially stretched to its maximum length? Explain.

(c) What is the acceleration of the two masses when they are connected by the string?

(d) What is the tension in the string, if any?

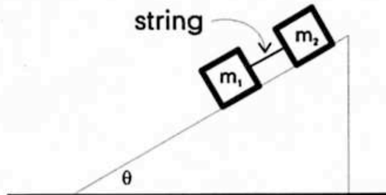

Figure 2: Figure for Problem 5.