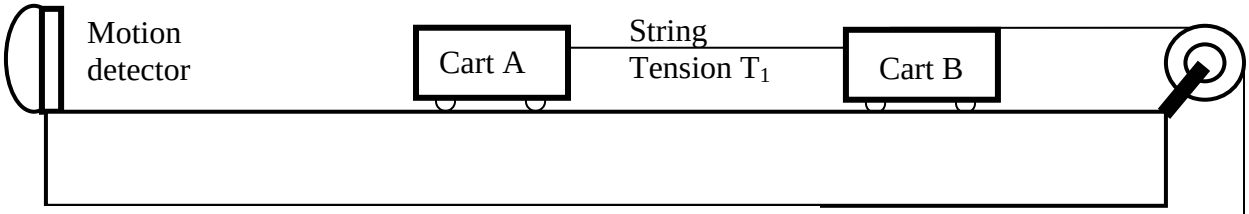
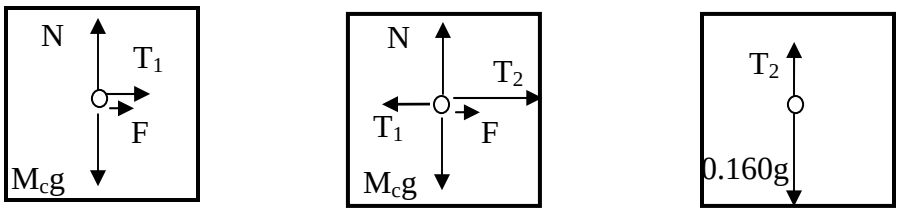
Name_____ Student ID_____ Score_____
last first

III. (25 pts)

Two carts of equal mass (M_c) and frictional properties are connected by a string. A second string passes over a pulley to a 160 g hanging weight. Your lab partner smoothly pushes Cart A toward the motion detector and then releases it so that the strings are all tight and Carts A and B are moving at the same speed. **The questions below all apply to motion after your partner has released the cart.**



A. (6 pts). Draw free body diagrams, labeling all forces, for Cart A, Cart B, and the Hanger, for the case that the carts are moving toward the motion detector, including friction on the carts.



Cart A Cart B Hanger

B. (6 pts) From your measurements you find (t is time, V is velocity, negative toward the sensor) (In computing your uncertainties ignore the time uncertainty and use the given velocity uncertainty.)

t = 3.00 S V = –0.71 ± .05 m/S
t = 3.50 S V = 0.00 ± .05 m/S
t = 4.11 S V = 0.71 ± .05 m/S

Give acceleration a_1 of the carts for motion toward the detector:

Give acceleration a_2 of the carts for motion away from the detector:

$a_1 = (V_2 - V_1)/(T_2 - T_1) = \Delta V/\Delta t = (0 + 0.71)/(3.50 - 3.00) = 1.42$ m/s^2
$\delta a_1 = \delta\Delta V/\Delta t = (\delta V_2^2 + \delta V_1^2)^{1/2}/\Delta t = \sqrt{2}\,(\delta V)/\Delta t = 0.14$ m/s^2
or, sum errors to get $\delta\Delta V = 2(\delta V) = 0.10$ m/s and $\delta a_1 = 0.20$ m/s^2
so $a_1 = 1.42 \pm 0.14$ or ± 0.20 m/s^2
$a_2 = (0 + 0.71)/(4.11 - 3.50) = 1.16 \pm 0.14$ m/s^2 (or ± 0.20) m/s^2

C. (6 pts) What is T_2 when the carts are moving toward the detector?

Use the Hanger, where F = ma gives $mg - T_2 = ma_1$
Then $T2 = m(g - a_1) = 0.160\,(9.8 - 1.42) \pm 0.160(0.14) = 1.34 \pm 0.22$ N
Note; the above numbers could be rounded to 2 significant figures, with a 1 significant figure error to match.
If we insist that the upward direction is positive, then the hanger's acceleration has opposite sign of the carts' and that equation would be written $T2 - mg = -ma_1$ which gives the same result.

D. (7 pts) What is T_1 when the carts are moving toward the detector? Explain.

Cart B has net force $T_2 - T_1 + F = M_c a_1$
Cart A has net force $T_1 + F = M_c a_1$
Equating these, we see $T_2 = 2T_1$, so $T_1 = (1.34 \pm 0.22)/2 = 0.67 \pm 0.11$ N
OR $T_2 + 2F$ is the net force on the pair of carts = $2 M_c a_1$ while $T_1 + F = M_c a_1$ for Cart A. These give the same result