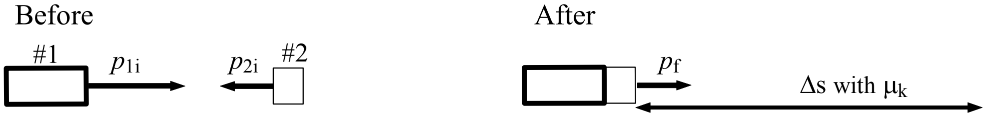
Name: ________________________________ **"Alphabetic" Student No.:** [ ]

HOMEWORK #6: Momentum (Phys 207, Fall 2005) **Do NOT forget units!!**

DUE on Monday, 10/31

Problem #1: 1-D Perfect Inelastic Collision (20 pts)

A semitruck (#1) and car (#2) are driving towards each other as shown below and have a **perfectly inelastic** head-on collision. After the collision, the two vehicles skid a distance Δs on the pavement (μ_k) before stopping.



(a) If the initial **kinetic energies** of the two vehicles are **equal**, then find an **algebraic expression** for the **ratio** v_{1i} / v_{2i} of the initial velocities for the semitruck v_{1i} and car v_{2i}. Assume that the semitruck has mass m_1 and the car has mass m_2.

(b) Using conservation of momentum, find an **algebraic expression** for the **velocity** v_f of the combined semitruck/car heap immediately after the collision. Which direction does it travel?

(c) Find the **numerical value** for the **velocity** v_f of the crash heap if the car initially travels at 30 m/s (or ~67 mph), and the truck weighs 4 times the car ($m_1 = 4m_2$). Use parts (a) and (b).

(d) Using the Work-Energy Theorem #2, find an **algebraic expression** for the **skid distance Δs**. Remember that here the "initial" kinetic energy refers to the energy just after the collision.

(e) Find the **numerical value** for the **skid distance Δs** of the crash heap if $\mu_k = 0.5$.

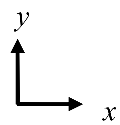
<u>Problem #2</u>: 2-D Perfect Inelastic Collision (40 pts)

Two blocks are moving on a frictionless, horizontal table. Block #1 (2 kg) has an **initial velocity** $\vec{v}_{1i} = (10\hat{i} + 10\hat{j})$ m/s and block #2 (2 kg) has an **initial velocity** $\vec{v}_{2i} = (-15\hat{i} + 5\hat{j})$ m/s .

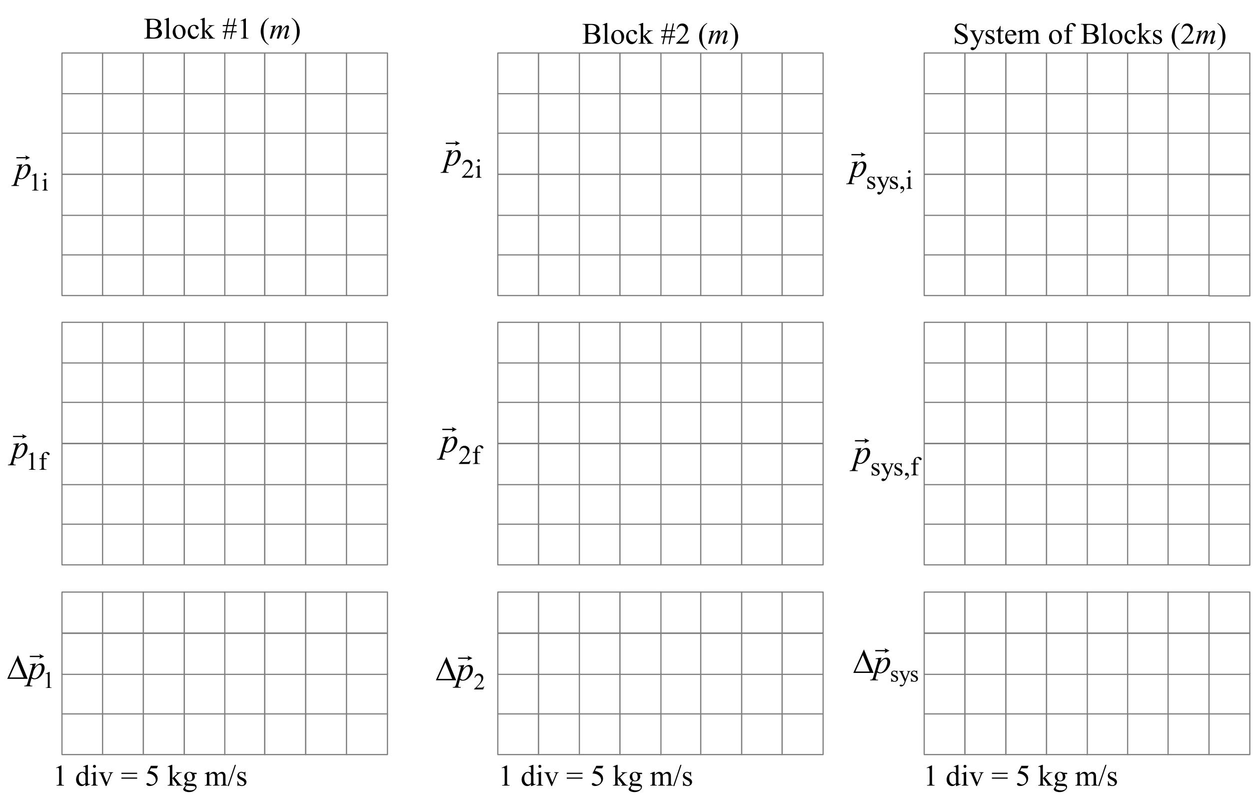
The two blocks then collide and stick together in a perfectly inelastic collision.

(a) Draw diagrams of the blocks below for **before** and **after** the collision. Label the blocks and draw the relevant momentum vectors $\vec{p}_{1i}$, $\vec{p}_{12}$, $\vec{p}_{f}$ in each picture.

Before Collison



After Collison



(b) Draw the **initial momenta** $\vec{p}_{i}$ for each block and the system on the grids and write their values below.

$\boxed{\vec{p}_{1i}} = m\vec{v}_{1i} = (2\text{ kg})(10\hat{i} + 10\hat{j})\text{ m/s} = \boxed{20\hat{i} + 20\hat{j}\text{ kg m/s}}$ (1st calculation done as an example!)

$\vec{p}_{2i} =$ $\vec{p}_{2i} = \boxed{}$

$\vec{p}_{sys,i} =$ $\vec{p}_{sys,i} = \boxed{}$

(c) Draw the **final momenta** $\vec{p}_f$ for each block and the system on the grids and write their values below.

$\vec{p}_{1f}$ =

$\vec{p}_{2f}$ =

$\vec{p}_{sys,f}$ =

(d) Draw the **change in momenta** $\Delta\vec{p}$ for each block and the system on the grids and write their values below.

$\Delta\vec{p}_1$ =

$\Delta\vec{p}_2$ =

$\Delta\vec{p}_{sys}$ =

(e) What observation can you make about **changes in momenta** $\Delta\vec{p}_1$ and $\Delta\vec{p}_{12}$? How does this relate to the forces on each block and Newton's 3rd Law pairs?

(f) Find the **initial kinetic energies** K_i of both blocks. Remember $K = \frac{m}{2}(v_x^2 + v_y^2) = \frac{1}{2m}(p_x^2 + p_y^2)$.

K_{1i} =

K_{2i} =

(g) Find the **final kinetic energies** K_f of both blocks.

K_{1f} =

K_{2f} =

h. Find the **change in kinetic energy** of the system of blocks.

ΔK_{sys} =

Problem #3: Elastic Collision with One Mass at Rest (20 pts)

Block #1 (m_1, v_{1i}) travels to the right on a frictionless, horizontal table and makes a head-on **elastic** collision with a stationary Block #2 (m_2).

(a) Draw below two diagrams of the blocks for **before** and **after** the collision. Label the blocks and draw the relevant momentum vectors (p_{1i}, p_{1f}, p_{2f}) in each picture. In this case, assume that Block #1 has a **larger mass** than Block #2.

(b) If $m_1 = 4m_2$ and block #1 travels at initial speed v, then find the **final velocities** of both blocks in terms of v. Indicate whether each block travels to the right or left.

(c) Find the **initial and final momenta** of the system for part (b) in terms of m_2 and v. Check that momentum is conserved.

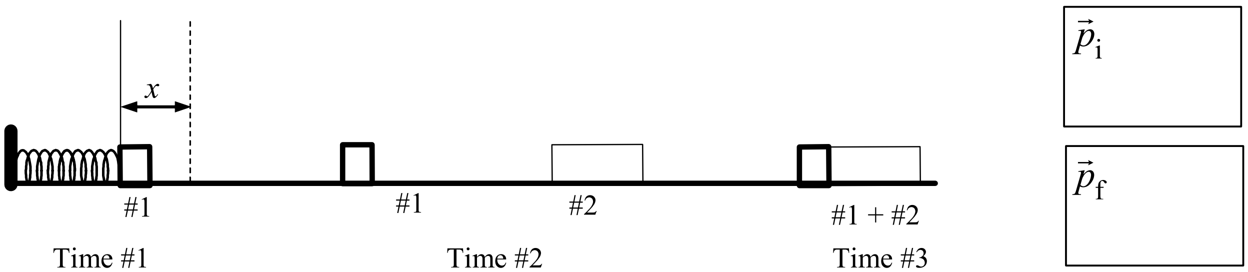
(d) If $m_1 = \frac{1}{4}m_2$ and block #1 travels at initial speed v, then find the **final velocities** of both blocks in terms of v. Indicate whether each block travels to the right or left.

(e) Find the **initial and final momenta** of the system for part (d) in terms of m_2 and v. Check that momentum is conserved.

<u>Problem #4</u>: Combination Momentum/Energy Problem (20 pts)

Block #1 (mass m) is pushed against a horizontal spring such that the spring is **compressed** by a **distance** $\boldsymbol{x}$ from its equilibrium length. The block is then released from the compressed spring and slides on a frictionless surface with **velocity** $\boldsymbol{v}$ until it collides with a stationary block #2 (mass $3m$). The collision is perfectly **inelastic**. The two blocks then travel together with **final velocity** $\boldsymbol{v_f}$.

(a) A picture of the problem is shown below for the time periods 1) before Block #1 is released, 2) after Block #1 is released, and 3) after Block #1 collides with Block #2. Draw and label the **velocity** vectors v and v_f on the blocks where necessary. Also, draw the **momentum** vectors of the system of blocks both **before** and **after** the collision in the provided boxes. Pay attention to the relative lengths of vectors.



(b) Using the work-energy theorem #2 (i.e., energy conservation), find an **algebraic** expression for the **velocity** $\boldsymbol{v}$ of block #1 before it collides with block #2.

(c) Using conservation of momentum, find an **algebraic** expression for the **final velocity** v_f of the blocks after the collision. Express it in terms of the initial variables m, k, x.

(d) If the compression **length** $\boldsymbol{x}$ of the spring is **halved**, how does the **final velocity** v_f of the two blocks change?