Momentum Worksheet

Full Name-Element Here:

0 Formulas

- $\vec{F}\Delta t = \Delta\vec{p} = m\Delta v$
- $\vec{p} = m\vec{v}$
- $\Delta\vec{x} = \vec{v}_i t + \frac{1}{2}\vec{a}t^2$
- $\vec{F}_g = m\vec{g}$
- $\Delta E = W = FD$

1 Multiple Choice

1. *Two ice skaters are skating across a flat pond, both are traveling in the positive $\hat{x}$ direction. One has more momentum, the other has more energy. A constant force is applied in order to stop the skiers. Which of these statements is true?*

   A. The skater with more energy will take a longer time to stop, but the skater with more momentum will go further before stopping.

   $\boxed{\text{B.}}$ The skater with more momentum will take a longer time to stop, but the skater with more energy will go further before stopping.

   C. The skater with more momentum will take a longer time to stop, and go further before stopping.

   D. The skater with more energy will take a longer time to stop, and go further before stopping.

2. *A vandal pushes a car (mass $m = 1000$ kg) off the edge of a parking garage. It initially has a momentum of 0.*

   (a) What will be the momentum after a time t?

   $\boxed{\text{A.}}$ $-mgt\ \hat{z}$
   B. $-mgh\ \hat{z}$
   C. $-gt\ \hat{z}$
   D. $-mg\ \hat{z}$
   E. 0

   (b) Explain how the situation conserved the momentum of the universe.

   The system has two interacting objects. The earth and the car. By Newton's third law, the gravity force that the car applies on the Earth is equal and opposite to the gravity force that the car applies to the earth. Since the times over which the forces act are the same, the impulses are equal and opposite so that momentum is conserved.

2 Free Response

1. *A model rocket with mass m_c has a constant momentum of $\vec{p}_c$.*

   (a) *What will be the rocket's displacement at time t? Use only variables given in the problem.*

$$\Delta\vec{r} = \frac{\vec{p}_c}{m}t$$

   (b) *If $m_c = 20$ kg and $\vec{p}_c = 20\ \mathrm{kg}\frac{\mathrm{m}}{\mathrm{s}}\hat{z}$, find the displacement of the rocket at $t = 10$ s.*

10 m

2. *Explain how an air bag can make a driver safer.*

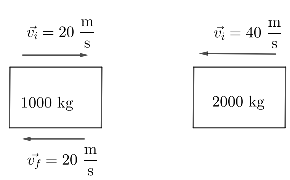
   The drivers change in momentum cannot be changed by the airbag, but the airbag makes the driver take longer to stop. Since $\Delta\vec{p} = \vec{F}t$ This reduces the force.

3. *The driver of a car decided to check his text messages while driving. As a result, two cars collide.*

   - Car 1: $M_1 = 1000$ kg and $v_{1,i} = 20\ \frac{\mathrm{m}}{\mathrm{s}}$ right.
   - Car 2: $M_2 = 2000$ kg and $v_{2,i} = 40\ \frac{\mathrm{m}}{\mathrm{s}}$ left.

   After the collision, Car 1 has a velocity of $v_{1,f} = 20\ \frac{\mathrm{m}}{\mathrm{s}}$ left

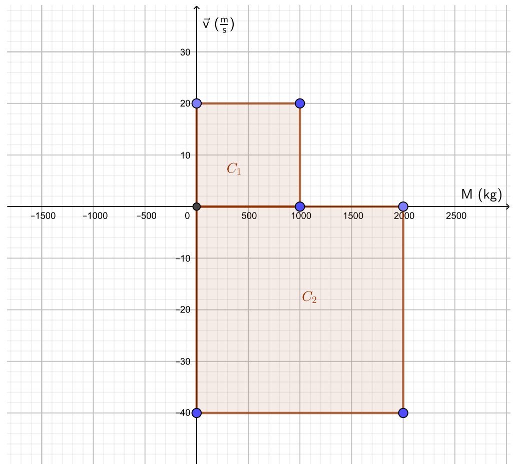
   (a) *Make a diagram of the situation.*



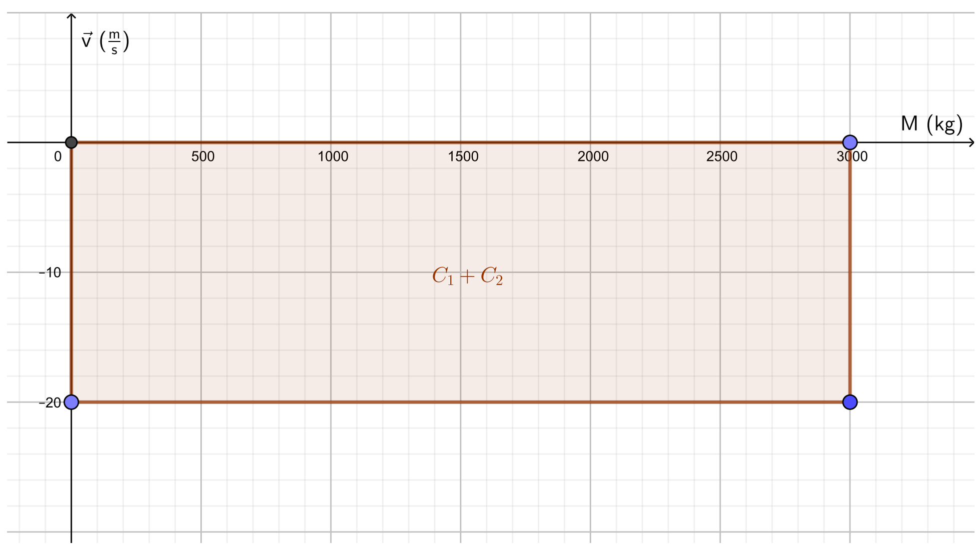
   (b) *Solve for the final velocity of car 2.*

$$\vec{v}_{2,f} = 20\ \frac{\mathrm{m}}{\mathrm{s}}\ \text{left}$$

(c) On the empty velocity/mass graph below, draw rectangles that represent the momentum of each car before the collision.



(d) On the empty velocity/mass graph below, draw rectangles that represent the momentum after the collision.



(e) *Classify the collision as perfectly elastic, partially elastic, or perfectly inelastic. Explain your answer.*

The collision is perfectly inelastic because the objects stick together and move as one.

4. *Two objects collide. The first object has a mass of* 200 kg *and the second object has a mass of* 400 kg. *Their velocities are given by*

$$\vec{v}_{1i} = \left(\frac{1}{2}\hat{\mathrm{x}} - \frac{1}{2}\hat{\mathrm{y}}\right) \ \frac{\mathrm{m}}{\mathrm{s}}$$

$$\vec{v}_{2i} = \left(\frac{-1}{2}\hat{\mathrm{x}} + \frac{1}{2}\hat{\mathrm{y}}\right) \ \frac{\mathrm{m}}{\mathrm{s}}$$

5 seconds later they have velocities that are given by

$$\vec{v}_{1f} = \left(-\hat{\mathrm{x}} + \frac{1}{2}\hat{\mathrm{y}}\right) \ \frac{\mathrm{m}}{\mathrm{s}}$$

$$\vec{v}_{2f} = \left(\hat{\mathrm{x}} + \frac{1}{2}\hat{\mathrm{y}}\right) \ \frac{\mathrm{m}}{\mathrm{s}}$$

What was the average net external force on the system?

$$\vec{F} = (-60\hat{\mathrm{x}} - 40\hat{\mathrm{y}}) \ \mathrm{N}$$