1D Collision Practice Name:________________________________

1. A 59 kg object is moving at 25 m/s to the left. It collides and sticks to a stationary 65 kg object.
   a. What type of collision is this?

      Perfectly inelastic

   b. What is the momentum of the 59 kg object before the collision?

      $p = 59 kg \times 25 \frac{m}{s} = 1475 \frac{kg \cdot m}{sec} \approx 1500 \frac{kg \cdot m}{sec}$

   c. What is the momentum of the 65 kg object before the collision?

      Since velocity is zero, momentum is zero

   d. What must the momentum of the combined object be after the collision?

      $1500 \frac{kg \cdot m}{s}$

   e. What is the total mass of the combined object?

      $59 kg + 65 kg = 124 kg$
      $\approx 120 kg$

   f. What is the velocity of the combined object after the collision?

      $p = mv \rightarrow \frac{p}{m} = v$

      $\frac{1475 \frac{kg \cdot m}{sec}}{124 kg} = 12 m/sec$

2. A 4.6 kg object is moving at 65.2 m/s to the right, it collides with a 6500 kg object. The 4.6 kg object bounces back and the 6500 kg object starts moving at 0.087 m/s to the right.
   a. What is the total momentum before the collision?

$$p = mv = 4.6\,kg \times 65.2\,m/s = 299.92\ \frac{kg\cdot m}{sec}$$

$$\approx 3.0\times10^{2}\ \frac{kg\cdot m}{sec}$$ to the right

   b. What must the total momentum be after the collision?

$$3.0\times10^{2}\ \frac{kg\cdot m}{sec}$$

   c. What is the momentum of the 4.6 kg object after the collision?

$$p_{total} = p_{4.6} + p_{6500}$$

$$p_{6500} = 6500\,kg \times 0.087\,m/s = 565.5\ \frac{kg\cdot m}{sec}$$ to the right

$$p_{4.6} = p_{total} - p_{6500} = -265.58\ \frac{kg\cdot m}{sec}$$

$$= 265.58\ \frac{kg\cdot m}{sec}\ \text{left}$$

$$= 270\ \frac{kg\cdot m}{sec}\ \text{left}$$

   d. What is the velocity of the 4.6 kg object after the collision?

$$\frac{p}{m} = v \rightarrow \frac{270\ \frac{kg\cdot m}{sec}}{4.6\,kg} = 57.73\,m/s\ \text{left}$$

58 m/s left

   e. What is the total kinetic energy of objects before the collision?

$$E_k = \frac{1}{2}(4.6)(65.2)^2 = 9777.39\,J$$

$$\approx 9800\,J$$

   f. What is the total kinetic energy of objects after the collision?

$$E_k = \frac{1}{2}(4.6)(57.73)^2 = 7665.33$$

$$E_k = \frac{1}{2}(6500)(0.087)^2 = 24.599$$

total $7689.93\,J$ $\approx 7700\,J$

   g. What type of collision is this?

Inelastic because kinetic energy decreased

3. A 2.0 kg object (Block A), initially travelling at 5.0 m/s to the right has a collision with a 2.0 kg object (Block B), initially travelling 7.0 m/s to the left. They apply a 20 Ns impulse to each other.
   a. What is the final velocity of each object?

Block A: Initial momentum $= 2.0\ kg \times 5.0\ m/s = 10\ \frac{kg \cdot m}{sec}$ right

Final momentum $= 10\ \frac{kg \cdot m}{sec} - 20\ \frac{kg\ m}{sec}$

$= -10\ \frac{kg\ m}{sec}$ right $= 10\ \frac{kg\ m}{sec}$ left

Final velocity is $\frac{10}{2} =$ 5.0 m/s left

Block B: $p_0 = 2 \times 7 = 14\ \frac{kg \cdot m}{sec}$ left $- 20 = \frac{6}{2}\ \frac{kg \cdot m}{sec}$ right $=$ 3.0 m/s right

   b. How much kinetic energy was converted to other forms of energy during the collision?

Block A's kinetic energy doesn't change

Block B's initial kinetic energy is

$\frac{1}{2}(2)(7)^2 = 49\ J$

Final kinetic energy of block B is

$\frac{1}{2}(2)(3)^2 = 9\ J$

$49 - 9 = 40\ J = 4.0 \times 10^1\ J$ energy is converted into other forms

4. A 56.0 kg object is moving at 2.8 m/s, it strikes and sticks to a stationary 24.0 kg object. How much kinetic energy was converted into other forms during the collision?

$$p_0 = 56 \times 2.8 = 156.8 \ \frac{kg \cdot m}{sec}$$

$$p_f = p_0 = (56\,kg + 24\,kg)\,V_f$$

$$V_f = \frac{156.8 \ \frac{kg \cdot m}{sec}}{80\,kg} = 1.96\,m/s$$

E_K before collision

$$\frac{1}{2}(56)(2.8)^2 = 219.52\,J$$

E_K after collision

$$\frac{1}{2}(80)(1.96)^2 = 153.664\,J$$

$$219.52\,J - 153.664\,J = 66\,J$$

66 J converted to other forms of energy

1D Collision Practice Name:____________________________________

5. A 1.0 kg ball moving at 6.0 m/s to the left, collides elastically with a stationary 2.0 kg ball.
   a. What is the total kinetic energy of the system before the collision?

$\frac{1}{2}(1)(6)^2 + \frac{1}{2}(2)(0)^2 = 18 J$

   b. What must the total kinetic energy of the system be after the collision?

18 J since it is elastic

   c. What is the total momentum of the system before the collision?

$1_{kg} \times 6 \frac{m}{s} + 2_{kg} \times 0 \frac{m}{s} = 6.0 \frac{kg \cdot m}{sec}$ to the left

   d. What is the total momentum of the system after the collision?

$6.0 \frac{kg \cdot m}{sec}$ to the left

   e. After the collision, the 2.0 kg ball is moving at 4.0 m/s to the left. How fast and I n what direction is the 1.0 kg ball moving?

$6.0 \frac{kg\,m}{sec}$ left $-$ $8.0\, kg \frac{m}{s}$ left $= \frac{2.0\, kg \frac{m}{s} \text{ right}}{1.0\, kg}$

$= 2.0 m/s$ right

   f. What is the kinetic energy of each ball after the collision? (remember kinetic energy is a scalar so will always be positive)

1 kg ball: $\frac{1}{2}(1)(2)^2 = 2 J$

2 kg ball $= \frac{1}{2}(2)(4)^2 = 16 J$

1D Collision Practice Name:______________________________________

East is positive

6. A 2.5 kg ball moving at 56 m/s East strikes a 26 kg ball moving at 21 m/s East. After the collision the 2.5 kg ball is moving 11 m/s West.
   a. What is the velocity of the 26 kg ball?

$p_{Ai} + p_{Bi} = p_{Af} + p_{Bf}$

$2.5 \times 56 = 140$, $26 \times 21 = 546$, $2.5 \times -11 = -27.5$

$686 \frac{kg \cdot m}{sec} = -27.5 \frac{kg \cdot m}{s} + p_{Bf}$

$713.5 = p_{Bf}$

$713.5 = 26 kg\, v_f$

$\frac{713.5 \frac{kg \cdot m}{s}}{26 kg} = 27.44 m/s$

$\approx 27 m/s$ East

   b. What is the magnitude of the impulse the balls give to each other?

Δp of 2.5 kg ball $= p_f - p_i$

$= -27.5 - 140 = -167.44 \frac{kg \cdot m}{sec}$

$167.44 \frac{kg \cdot m}{sec} \approx 170 \frac{kg \cdot m}{sec}$

   c. If the collision lasts 0.023 seconds, what force do the ball apply to each other?

$\frac{\Delta p}{t} = F \rightarrow \frac{167.44 Ns}{0.023 sec}$

$= 7280 N$

$\approx 7300 N$

7. A 3.1 kg object collides with and sticks to a stationary 4.8 kg object, after the collision they move at 5.6 m/s. What was the initial speed of the 3.1 kg object?

$$p_i = p_f = (3.1+4.8)(5.6) = 44.24\ \frac{kg\,m}{sec}$$

$$p_i = mv \rightarrow v = \frac{p_i}{m} = \frac{44.24\ \frac{kg\cdot m}{sec}}{3.1\ kg} = 14\ m/s$$

8. A 5.0 kg object is moving at 25 m/s to the West and strikes another 5.0 kg object moving at 25 m/s to the East.
   a. ~~What is the velocity of each of the objects after the collision?~~

   b. How much kinetic energy was converted into other forms of energy during the collision?

Since there is no motion after the collision all kinetic energy is converted

$$2 \times \left(\tfrac{1}{2}mv^2\right) = 3125\ J \approx 3100\ J$$

9. A ballistic pendulum is a device used to measure the velocity of a projectile. A 0.031 kg bullet is fired into a 10.0 kg block of wood hanging from a string. The wood block then swings upward to a height of 0.35 m above where it started.
   a. How much potential energy did the block have at its highest point?

$$E_p = mgh = 10.031\,kg \times 9.8\,\frac{m}{s^2} \times 0.35\,m$$
$$= 34.41\,J$$

   b. Assuming there was negligible friction in the rope how much kinetic energy did the block/bullet system have when the bullet was lodged into the block?

$$E_K = E_p = 34.41\,J$$

   c. What was the velocity of the block/bullet system immediately after being struck?

$$E_K = \frac{1}{2}mv^2$$

$$\sqrt{\frac{2E_K}{m}} = V \rightarrow \sqrt{\frac{2(34.41)}{10.031}} = 2.619\,m/s$$
$$\approx 2.6\,m/s$$

   d. Using conservation of momentum what was the velocity of the bullet just before it hit the block?

$$p_0 = \text{bullet}$$

$$p_F = \text{bullet/block} = mV = 10.031\,kg \times 2.619\,m/s$$
$$= 26.2728\,\frac{kg \cdot m}{sec}$$

$$26.2728\,\frac{kg\,m}{s} = m_{bullet} \cdot V_{bullet}$$

$$\frac{26.2728\,\frac{kg\,m}{sec}}{0.031\,kg} = 847.5\,\frac{m}{s} \approx 850\,m/s$$

Make left positive

10. A 20.0 kg block sliding at 5.0 m/s to the left collides with a 30.0 kg block sliding at 6.0 m/s to the right. The blocks apply a force of 900.0 N to each other during the collision for 0.21 seconds. The blocks then move apart over a surface with $\mu = 0.17$. How far apart are the blocks when they stop?

Impulse = 900 N × 0.21 sec = 189 Ns

20 kg block initial momentum is $100 \frac{kgm}{sec} - 189 \frac{kgm}{sec} = -89 \frac{kgm}{s}$

Final velocity is $-\frac{89}{20} = -4.45$ km/s

30 kg block initial momentum is $-180 \frac{kgm}{sec} + 189 \frac{kgm}{sec} = 9 \frac{kgm}{sec}$

final velocity is $\frac{9}{30} = 0.3$ m/s

F_{fric} on 20 kg block $= \mu F_N = 0.17 \times 20 \times 9.8 = 33.32$ N

"a" of 20 kg block is $\frac{33.32}{20} = 1.666\ m/s^2$

distance the 20 kg block travels is found using $V_f^2 = V_0^2 + 2ad$

V_f ↑ 0; V_0 ↑ -4.45 m/s; a ↖ $1.666\ m/s^2$ ↖ positive because it is in opposite direction to velocity

$d = -5.94$ m

For 30 kg block

$F_{Fric} = 49.98$

$a = -1.666$

↗ negative because to right

d of 30 kg block is 0.027m

Total distance apart

5.94m + 0.027m

= 5.967m ≈ 6.0m

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11. A 1100 kg car rear ends a stationary 1600 kg truck. Together they slide 6.0 m over a surface with $\mu = 0.42$. How fast was the car travelling when it hit the truck?

$m_{total} = 1100 kg + 1600 kg = 2700 kg$

a when slowing due to friction $= \frac{F_{Fric}}{m} = \frac{\mu m g}{m} = \mu g$

$= 4.116 m/s^2$

opposite motion

to find v_0 of m_{total} use

$v_f^2 = v_0^2 + 2ad$

~~$0 = v_0^2 + 2(-4.116)(6.0)$~~

$v_f = 0, \quad v_0 = ?, \quad a = -4.116 m/s^2 \quad d = 6.0 m$

$v_0 = 7.028 m/s$

p before collision = p after collision

$= 2700 kg \times 7.028 m/s$

$= 18975 \frac{kg\,m}{sec}$

$18975 \frac{kg\,m}{sec} = 1100 kg\ v$

$\frac{18975 \frac{kg\,m}{sec}}{1100 kg} = 17 m/s$