KEY

First Name:_____ Last Name:_____

L06 – Worksheet – Collisions in 1-Dimension, Elastic & Inelastic Collisions

Textbook Questions

Pg 476 #1: A 110-kg astronaut and a 4000-kg spacecraft are attached by a tethering cable. Both masses are motionless relative to an observer a slight distance away from the spacecraft. The astronaut wants to return to the spacecraft, so he pulls on the cable until his velocity changes to 0.80 m/s [toward the spacecraft] relative to the observer. What will be the change in velocity of the spacecraft?

Astronaut: $m_A = 110\,kg$, $v_A = 0.80\,m/s\ [F]$

Spacecraft: $m_S = 4000\,kg$, $v_S = ?$

$\vec{P}_{sys_i} = \vec{P}_{sys_f}$

$\vec{P}_{sys_i} = \vec{P}_{a_f} + \vec{P}_{s_f}$

$0 = (110)(+0.80) + (4000)\vec{v}_{s_f}$

$-88 = 4000\vec{v}_{s_f}$

$\vec{v}_{s_f} = -0.022\,m/s\ [F]$

$v_{s_f} = 0.022\,m/s$ [toward astronaut]

Pg 476 #2: A student is standing on a stationary 2.3-kg skateboard. If the student jumps at a velocity of 0.37 m/s [forward], the velocity of the skateboard becomes 8.9 m/s [backward]. What is the mass of the student?

Student: $m_A = ?$, $v_A = 0.37\,m/s\ [F]$

Skateboard: $m_B = 2.3\,kg$, $v_B = -8.9\,m/s\ [F]$

$\vec{P}_{sys_i} = \vec{P}_{sys_f}$

$\vec{P}_{A_i} + \vec{P}_{B_i} = \vec{P}_{A_f} + \vec{P}_{B_f}$

$0 + 0 = m_A(0.37) + (2.3)(-8.9)$

$m_A = 55.32\,kg$

KEY

Pg 477 #1: A student on a skateboard, with a combined mass of 78.2 kg, is moving east at 1.60 m/s. As he goes by, the student skillfully scoops his 6.4-kg backpack from the bench where he had left it. What will be the velocity of the student immediately after the pickup?

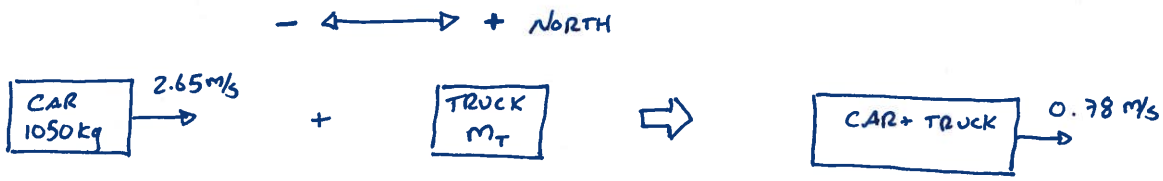
$m_A = 78.2\,kg$, $v_A = 1.60\,m/s$ + $m_B = 6.4\,kg$, $v_B = 0$ ⇨ $m_{AB} = 84.6$, $v_{AB} = ?$

$$\vec{p}_{A_i} + \vec{p}_{B_i} = \vec{p}_{AB_f}$$

$$(78.2)(1.60) + (6.4)(0) = (84.6)\,v_{AB}$$

$$v_{AB} = 1.48\ m/s\ [E]$$

Pg 477 #2: A 1050-kg car at an intersection has a velocity of 2.65 m/s [N]. The car hits the rear of a stationary truck, and their bumpers lock together. The velocity of the car-truck system immediately after collision is 0.78 m/s [N]. What is the mass of the truck?



$$\vec{p}_{C_i} + \vec{p}_{T_i} = \vec{p}_{CT_f}$$

$$(1050)(2.65) + (m_T)(0) = (1050 + m_T)(0.78)$$

$$2782.5 + 0 = 819 + (m_T)(0.78)$$

$$1963.5 = (m_T)(0.78)$$

$$m_T = 2517.3\ kg$$

KEY

Pg 478 #1: A 0.25-kg volleyball is flying west at 2.0 m/s when it strikes a stationary 0.58-kg basketball dead center. The volleyball rebounds east at 0.79 m/s. What will be the velocity of the basketball immediately after impact?

$\vec{P}_{BB_i} + \vec{P}_{VB_i} = \vec{P}_{BB_f} + \vec{P}_{VB_f}$

$(0.58)(0) + (0.25)(-2.0) = (0.58)\vec{v}_{BB_f} + (0.25)(+0.79)$

$0 + -0.5 = (0.58)\vec{v}_{BB_f} + 0.1975$

$-0.6975 = (0.58)\vec{v}_{BB_f}$

$\vec{v}_{BB_f} = -1.20\ m/s\ [E]$ or $1.20\ m/s\ [W]$

Pg 478 #2: A 9500-kg rail flatcar moving forward at 0.70 m/s strikes a stationary 18,000-kg boxcar, causing it to move forward at 0.42 m/s. What will be the velocity of the flatcar immediately after collision if they fail to connect?

$\vec{P}_{FC_i} + \vec{P}_{BC_i} = \vec{P}_{FC_f} + \vec{P}_{BC_f}$

$(9500)(0.70) + (18,000)(0) = (9500)\vec{v}_{FC_f} + (18,000)(0.42)$

$6650 + 0 = 9500\,v_{FC_f} + 7560$

$-910 = (9500)\vec{v}_{FC_f}$

$\vec{v}_{FC_f} = -0.0958\ m/s\ [f]$

$= 0.0958\ m/s\ [backward]$

KEY

Pg 479 #1: A 72-kg snowboarder gliding at 1.6 m/s [E] bounces west at 0.84 m/s immediately after colliding with an 87-kg skier travelling at 1.4 m/s [W]. What will be the velocity of the skier just after impact?

$\vec{P}_{B_i} + \vec{P}_{S_i} = \vec{P}_{B_f} + \vec{P}_{S_f}$

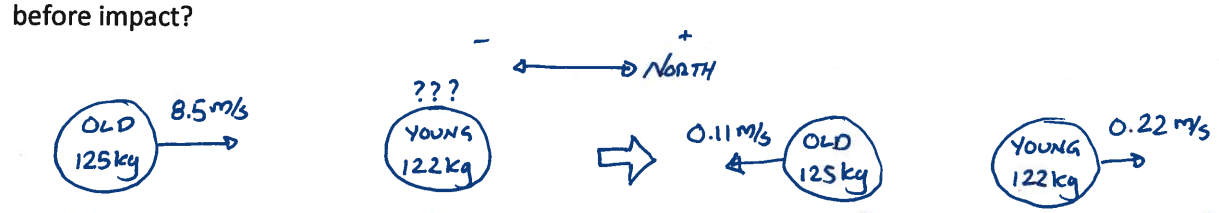
$(72)(+1.6) + (87)(-1.4) = (72)(-0.84) + (87)\vec{v}_{S_f}$

$115.2 + -121.8 = -60.48 + (87)\vec{v}_{S_f}$

$53.88 = (87)\vec{v}_{S_f}$

$\vec{v}_{S_f} = 0.619 \text{ m/s [E]}$

Pg 479 #2: A 125-kg bighorn ram butts heads with a younger 122-kg ram during mating season. The older ram is rushing north at 8.50 m/s immediately before the collision, and bounces back at 0.11 m/s [S]. If the younger ram moves at 0.22 m/s [N] immediately after collision, what was its velocity just before impact?



$(125)(8.50) + (122)\vec{v}_{y_i} = (125)(-0.11) + (122)(+0.22)$

$1062.5 + (122)v_{y_i} = -13.75 + 26.84$

$(122)v_{y_i} = -1049.41$

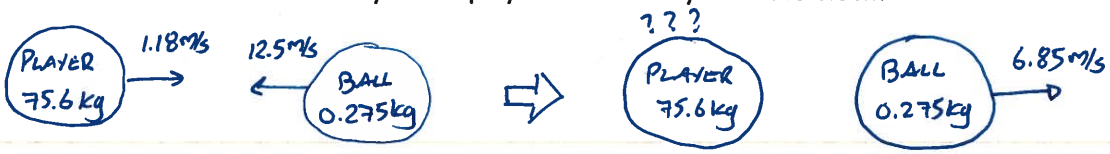
$v_{y_i} = -8.60 \text{ m/s [N]}$

$= 8.60 \text{ m/s [S]}$

KEY

Pg 486 #10: A 75.6-kg volleyball player leaps toward the net to block the ball. At the top of his leap, he has a horizontal velocity of 1.18 m/s [right], and blocks a 0.275-kg volleyball moving at 12.5 m/s [left]. The volleyball rebounds at 6.85 m/s [right].

a. What will be the horizontal velocity of the player immediately after the block?



$\vec{P}_{PL_i} + \vec{P}_{B_i} = \vec{P}_{PL_f} + \vec{P}_{B_f}$

$(75.6)(+1.18) + (0.275)(-12.5) = (75.6)\vec{v}_{L_f} + (0.275)(+6.85)$

$89.208 + -3.4375 = (75.6)\vec{v}_f + 1.88375$

$83.88675 = (75.6)\vec{v}_f$

$\vec{v}_f = 1.1096 \text{ m/s [R]}$

b. Determine if the collision is elastic.

$E_{K_i} = E_{K_{PL_i}} + E_{K_{B_i}}$

$= \frac{1}{2}(75.6)(1.18)^2 + \frac{1}{2}(0.275)(12.5)^2$

$= 52.63272 + 21.484375$

$= 74.117095 \text{ J}$

$E_{K_f} = E_{K_{PL_f}} + E_{K_{B_f}}$

$= \frac{1}{2}(75.6)(1.1096)^2 + \frac{1}{2}(0.275)(6.85)^2$

$= 46.5398 + 6.4518$

$= 52.9917 \text{ J}$

$E_{K_i} \neq E_{K_f}$

So not elastic.

[redacted]

Diploma Worksheet Questions

Q29: Two railway cars, each of mass m_1, are approaching each other on a straight line with the same constant speed v. Their total kinetic energy E_k and total momentum $\vec{p}$ are

a. $E_k = mv^2, \vec{p} = 2m\vec{v}$
b. $E_k = \frac{1}{2}mv^2, \vec{p} = m\vec{v}$
c. $E_k = mv^2, \vec{p} = 0$
d. $E_k = 0, \vec{p} = 2m\vec{v}$

CAR 1 → ← CAR 2

$\vec{p} = +mv$ $\quad$ $\vec{p} = -mv$

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

$\vec{P}_{TOT} = \vec{P}_1 + \vec{P}_2$

$= +mv \quad -mv$

$= 0$

$E_{K_{TOT}} = E_{K_1} + E_{K_2}$

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

$= mv^2$

Use the following information to answer Q37:

> A lump of clay with a mass of 50.0 g is moving south at a speed of 20.0 cm/s. It collides head on with a second lump of clay with a mass of 70.0 g that is moving north at a speed of 40.0 cm/s.

Q37: The two lumps stick together, and no external horizontal forces act on the system. The **velocity** of the combined lump after the collision is

a. 60.0 cm/s, south
b. 31.7 cm/s, south
c. 20.0 cm/s, north
d. 15.0 cm/s, north

− ⟷ + NORTH

Check out units. Everything, including answers, are in cm/s and grams. Keep these units.

70g → 40cm/s $\quad$ 20cm/s ← 50g $\quad\Rightarrow\quad$??? 120g

$\vec{P}_{A_i} + \vec{P}_{B_i} = \vec{P}_{AB_f}$

$(70)(40) + (50)(-20) = (120)\vec{v}_f$

$2800 + -1000 = (120)\vec{v}_f$

$1800 = (120)\vec{v}_f$

$\vec{v}_f = 15 \text{ cm/s } [N]$

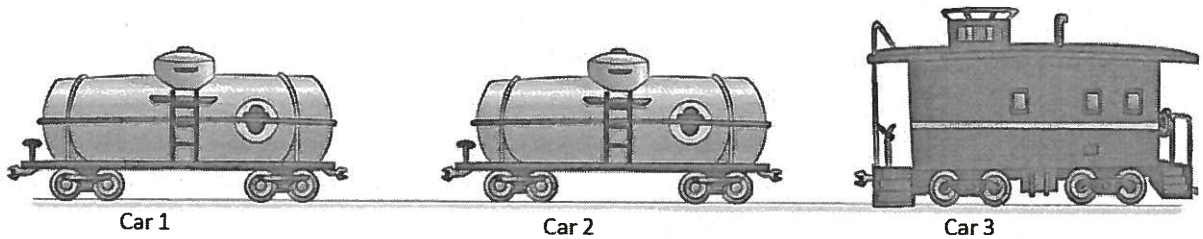
KEY

Challenge Question

Use the following information to answer Q1-Q2:

Train Car Collision

An empty train car, labelled *Car 1*, with a mass of 2000 kg is travelling with an initial velocity of 2.5 m/s [R]. Two other train cars are present, and are currently stationary.



Car 1
m = 2000 kg
v_i = 2.5 m/s [R]

Car 2
m = 3000 kg
v_i = 0.0 m/s [R]

Car 3
m = 1000 kg
v_i = 0.0 m/s [R]

Collision #1: *Car 1* collides with *Car 2*, and rebounds at 0.50 m/s [L], while *Car 2* travels forward to the right.

Collision #2: *Car 2* collides with *Car 3*. The two cars lock together and travel as a single unit after the collision.

Q1: Immediately after **Collision #1,** the speed of *Car 2* is ____ m/s [R].

*(Record your **three digit** answer in the Numerical Response boxes below)*

2	.	0	0

CAR 1 2000kg → 2.5 m/s; CAR 2 3000kg

$(2000)(+2.5) + (3000)(0) = (2000)(-0.5) + (3000)v_f$

$5000 + 0 = -1000 + (3000)v_f$

$v_f = 2.0$ m/s [R]

Q2: Immediately after **Collision #2**, the speed of *Cars 2&3* is ____ m/s [R].

*(Record your **three digit** answer in the Numerical Response boxes below)*

1	.	5	0

CAR 2 3000 kg → 2.0 m/s; CAR 3 1000 kg → ??? CAR 2+3 4000 kg

$(3000)(2) + (1000)(0) = (4000)v_f$

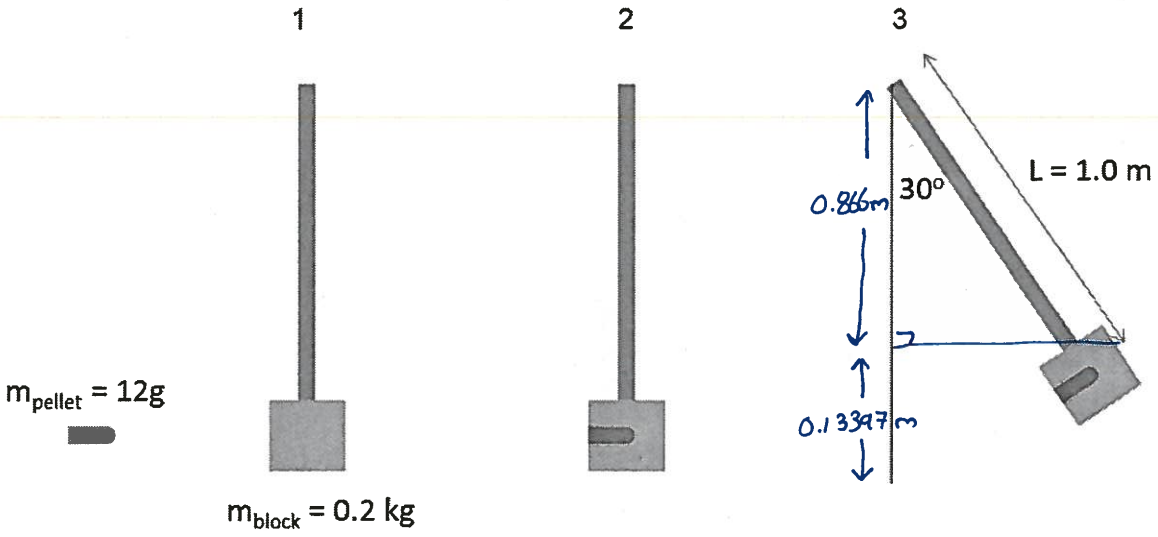
$6000 + 0 = (4000)v_f$

$v_f = 1.50$ m/s [R]

KEY

Use the following information to answer Q3:

A 12g airsoft pellet strikes a 0.2 kg mass on the end of a 1.0m string. The pendulum arm swings 30^0 after the impact.



Q3: The initial speed of the airsoft pellet, prior to impact, is ***a.bc*** x 10^d m/s, where ***a, b, c,*** and ***d*** are ___, ___, ___, and ___.

*(Record your **four digit** answer in the Numerical Response boxes below)*

Ep of Block + Bullet

$E_p = mgh$

$= (0.212)(9.81)(0.13397)$

$= 0.278629647242\ J$

E_K of Block + Bullet ⇐

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

$0.2786\ldots = \frac{1}{2}(0.212)v^2$

$v = 1.62129\ m/s$ ⇐

COLLISION

$\vec{P}_{B_i} + \vec{P}_{Block_i} = \vec{P}_{sys_f}$

$(0.012)v_i + (0.2)(0) = (0.212)(1.62129\ldots)$

$(0.012)v_i + 0 = 0.343713500507$

$v_i = 28.6427917089\ m/s$

$v_i \approx 28.6\ m/s$ (or 103.1 km/h)