Momentum and Impulse

WORKSHEET #1

Name: ________________________

1. When you catch a baseball, it can hurt. It hurts less if one 'goes with the ball'. This is because:
a. This makes the KE less
b. This makes the momentum change less
c. This makes the time interval for stopping greater
d. This makes the impulse less

2. If two objects have an inelastic collision and one is initially at rest, is it possible for both of them to be at rest after the smash up? Is it possible for only one of them to be at rest? How come?

An inelastic collision with only one object at rest before the collision would have a non-zero total momentum. If both were at rest after the collision, you'd have a non-zero number (momentum before collision) equaling zero (momentum after collision). Not possible. Only way to have zero after is to have both zero before or both moving in opposite directions with equal and opposite momenta before the collision.

If only one was at rest before the collision, and one is at rest after the collision, then all of the momentum is transferred from the first object to the second object, so theoretically this is possible.

3. In a bizarre carnival activity you are required to catch a tennis ball and an iron ball. The tennis ball you catch easily. Next, a solid metal (iron) ball of the same diameter is to be thrown to you. You are given the following choices: same kinetic energy, same velocity, or same momentum. Which of them would be the best choice to give you the easiest catch? How come?

"Easiest to catch" would mean the slowest velocity toward you for the iron ball. Same velocity would be the fastest, so not a good choice. Same momentum, the velocity of the ball would vary inversely with the mass. So, an iron ball 4x the mass would have a 1/4 v. Same kinetic energy, the square of the velocity of the ball would vary inversely with the mass, so a ball with 4x mass would have $\frac{1}{2}$ v. So, same momentum would be easiest: lowest "v" and smallest impulse to stop it.

4. Okay, what is the magnitude of the momentum of a proton that is traveling at 2.35×10^5 m/s?

$p = mv = (1.67 \times 10^{-27}\text{ kg})(2.35 \times 10^5\text{ m/s}) = 3.9245 \times 10^{-22}\text{ kg·m/s} = \boxed{3.92 \times 10^{-22}\text{ kg·m/s}}$

5. It takes you all of 0.018 s to initially touch and then catch a 0.600 kg football travelling at 16.0 m/s. (a) What is the change in momentum for the football? (b) What is the impulse? (c) What is the force that must be exerted to stop the ball?

a. $\Delta p = m\Delta v = 0.600\text{ kg} \cdot 16.0\text{ m/s} = \boxed{9.60\text{ kg·m/s}}$
b. $J = F \cdot t = \Delta p$
   $J = \boxed{9.60\text{ kg·m/s}}$
c. $F = J/t = 9.60\text{ kg·m/s} / 0.018\text{s} = 533.33\text{ N} = \boxed{530\text{ N}}$

6. You throw a 0.345 kg ball straight up with an initial velocity of 13.5 m/s. (a) What is the momentum of the ball at the highest point of its path? (b) What is its momentum halfway up? (c) What is its kinetic energy halfway up?

a. $p = mv = 0.345\text{ kg} \cdot 0\text{ m/s} = \boxed{0.00\text{ kg}\cdot\text{m/s}}$

b. $PE = KE$

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

$gh = \frac{1}{2}v^2$

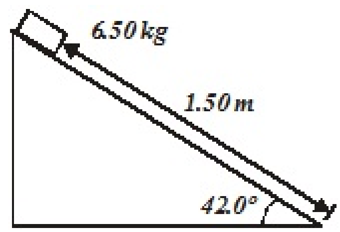
$h = v^2/2g = (13.5\text{ m/s})^2 / (2 \cdot 9.8\text{ m/s}^2) = 9.298469388\text{ m}$

$v = (2gh)^{\frac{1}{2}} = (2 \cdot 9.8\text{ m/s}^2 \cdot 4.649234694\text{ m})^{\frac{1}{2}} = 9.545941546\text{ m/s}$

$p = mv = 0.345\text{ kg} \cdot 9.545941546\text{ m/s} = 3.293349833\text{ kg}\cdot\text{m/s} = \boxed{3.29\text{ kg}\cdot\text{m/s}}$

c. $KE = \frac{1}{2}mv^2 = 0.5 \cdot 0.345\text{ kg} \cdot (9.545941546\text{ m/s})^2 = 15.7190625\text{ J} = \boxed{15.7\text{ J}}$

7. A 6.50 kg block slides down a ramp that is elevated at 42.0° a distance of 1.50 m. The coefficient of kinetic friction is 0.235. (a) What is the potential energy of the block before it begins to slide? (b) What is the work done by friction as the block slides down the ramp (said energy being converted into heat)? (c) What is the speed of the block when it reaches the bottom? (d) What is the average acceleration of the block down the ramp? (e) What is the momentum of the block at the bottom of the ramp?



a. $h = 1.50\text{ m} \cdot \sin(42.0°) = 1.00369591\text{ m}$

$PE = mgh = 6.50\text{ kg} \cdot 9.8\text{ m/s}^2 \cdot 1.00369591\text{ m} = 63.9354294\text{ J} = \boxed{63.9\text{ J}}$

b. $F_{fric} = \mu F_N = \mu mg\cos\theta = 0.235 \cdot 6.50\text{ kg} \cdot 9.8\text{ m/s}^2 \cdot \cos(42.0°) = 11.1245065\text{ N}$

$W = F \cdot d = 11.1245065\text{ N} \cdot 1.5\text{ m} = 16.6867598\text{ N}\cdot\text{m} = \boxed{16.7\text{ J}}$

c. $KE = PE - W_{fric} = 63.9354294\text{ J} - (11.1245065\text{ N} \cdot 1.50\text{ m}) = 47.24866965\text{ J}$

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

$v = (2KE/m)^{\frac{1}{2}} = (2 \cdot 47.24866965\text{ J}/6.50\text{ kg})^{\frac{1}{2}} = 3.812879778\text{ m/s} = \boxed{3.81\text{ m/s}}$

d. $v^2 = v_i^2 + 2ad$

$a = (v^2 - v_i^2) / 2d = (3.812879778\text{ m/s})^2 / (2 \cdot 1.50\text{ m}) = 4.8460174\text{ m/s}^2 = \boxed{4.85\text{ m/s}^2}$

{kinematics double check}:

$a = F_{net}/m = (F_{para} - F_{fric})/m = (6.50\text{ kg} \cdot 9.8\text{ m/s}^2 \cdot \sin(42.0°) - 11.1245065\text{ N})/6.50\text{ kg} = 4.85\text{ m/s}^2$

e. $p = mv = 6.50\text{ kg} \cdot 3.812879778\text{ m/s} = 24.78371856\text{ kg}\cdot\text{m/s} = \boxed{24.8\text{ kg}\cdot\text{m/s}}$

8. A 750.0 g ball is thrown. It travels a distance of 58.0 m and is in the air for a total time of 1.65 s. Ignoring wind resistance and assuming that it is caught at the same height it was thrown from, find: (a) the horizontal velocity of the ball, (b) the initial vertical velocity of the ball, (c) the maximum height the ball reaches, (d) the launch angle of the ball, and (e) the kinetic energy of the ball when it is first thrown.

a. $v = d/t = 58.0\ m/1.65\ s = 35.15151515\ m/s = \boxed{35.2\ m/s}$

b. $v = v_i + at$

$-v_i = v_i + at$

$v_i = -at/2 = -(-9.8\ m/s^2)(1.65\ s)/2 = 8.085\ m/s = \boxed{8.1\ m/s}$

c. $v^2 = v_i^2 + 2ad$

$0 = (8.085\ m/s)^2 + 2(-9.8\ m/s^2)d$

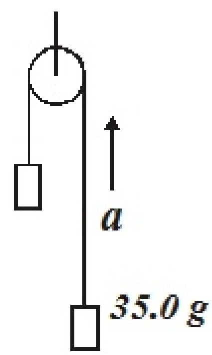
$d = -(8.085 m/s)^2/-19.6\ m/s^2 = 3.3350625\ m = \boxed{3.34\ m}$

d. $\theta = \tan^{-1}(8.085\ m/s\ /\ 35.15151515\ m/s) = 12.95299907022° = \boxed{13.0°}$

e. $v = ((35.151515\ m/s)^2 + (8.085\ m/s)^2)^{\frac{1}{2}} = 36.06932536\ m/s$

$KE = \frac{1}{2}mv^2 = 0.5 \cdot 0.7500\ kg \cdot (36.06932536\ m/s)^2 = 487.8735869\ J = \boxed{488\ J}$

9. A low friction pulley, light string deal with two masses is set up as shown. If the acceleration of the system is 0.225 m/s², what is the mass of the other weight?



$F_{netsys} = m_{wyw} \cdot a_{sys}$

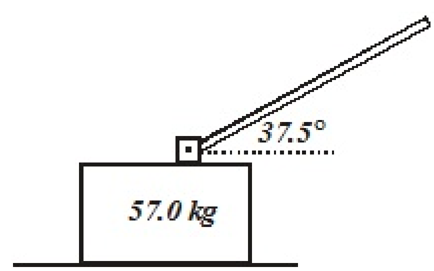
$m \cdot 9.8\ m/s^2 - 0.035\ kg \cdot 9.8\ m/s^2 = (m + 0.035\ kg) \cdot 0.225\ m/s^2$

$9.8m\ m/s^2 - 0.343\ kg{\cdot}m/s^2 = 0.225m\ m/s^2 + 0.007875\ kg{\cdot}m/s^2$

$9.575m\ m/s^2 = 0.350875\ kg{\cdot}m/s^2$

$m = 0.350875\ kg{\cdot}m/s^2\ /\ 9.575\ m/s^2 = 0.0366449086 = \boxed{36.6\ g}$

10. A heavy crate rests on the deck. The coefficient of kinetic friction is 0.225. A rigid rod is attached to the crate and is used to push it. If a force of 235 N is applied to the rod, what is the acceleration of the box?



$F_N = w + F_{push} \cdot \sin(37.5°)$

$= 57.0\ kg \cdot 9.8\ m/s^2 + 235\ N \cdot \sin(37.5°) = 701.6589358\ N$

$F_{fric} = \mu F_N = 0.225 \cdot 701.6589358\ N = 157.87326056\ N$

$F_{net} = F_{push} \cdot \cos(37.5°) - F_{fric}$

$= 235\ N \cdot \cos(37.5°) - 157.87326056$

$= 28.5647744\ N$

$a = F_{net}/m = 28.5647744\ N/57.0\ kg = 0.501136 = \boxed{0.50\ m/s^2}$