Lab - Review Sheet
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AP Physics
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Chapter 9 - Momentum

Summary - Momentum Is a measure of the quantity of motion that an object has; it takes into account both how fast the object is moving, and its mass. It characterizes the "quantity of motion" of an object.

Important Formulae	Uses
$p = m$v	Equation to calculate momentum
F = dp/dt	Equation relating force to change in momentum
$J = \int_{ti}^{tf} F dt = \Delta p$	Ways to calculate impulse/change in momentum
$p1 + p2 = p1' + p2'$	Law of conservation of momentum
$cm = \frac{\Sigma m_i x_i}{\Sigma m_i}$	Center of mass
$\sum p_{x1} + \sum F \Delta t = \sum p_{x2}$	Modified conservation of momentum

Key Points
linear momentum: ● Quantity of motion ● Caused by a force applied over time
impulse ● Amount of force applied over a given time ● A change in momentum
Conservation of Momentum ● Similarly to conservation of energy, this states that when two or more particles interact without outside forces, their total linear momentum stays the same ● p1 + p2 = p1' + p2'
Types of Collisions

- Inelastic collisions
  - Collision where some energy is lost to heat
- Perfectly inelastic collision
  - An inelastic collision where the objects stick together after collision
- Elastic collision
  - A collision where KE is conserved

FRQ #1

A 10.0 kg gun with an 80.0 cm long barrel fires a 130-gram bullet to the right with a velocity of +400 m/s.

1. Calculate the acceleration of the bullet while in the barrel of the gun.
   a. The bullet starts out with an initial velocity of zero, but then after being fired, exits the gun with a velocity of +400 m/s (to the right). Using kinematics to find the acceleration:

      $v_f^{\ 2} = v_i^{\ 2} + 2a\Delta x$

      $a = \frac{v_f^{\ 2} - v_i^{\ 2}}{a\Delta x}, a = 1.0x10^5\ m/s^2$

2. Calculate the time over which the bullet accelerated.

   $v_f = v_i + a\Delta t$

   $\Delta t = \frac{v_f - v_i}{a}$

   $\Delta t = \frac{400m/s - 0m/s}{1.0 \times 10^5 m/s^2}$

   $\Delta t = 0.0040s$

3. Calculate the average Force, magnitude and direction, applied by the gun to the bullet.

   $F_{net} = ma\ F_{net} = (0.130kg)(1.0 \times 10^5 m/s^2)$

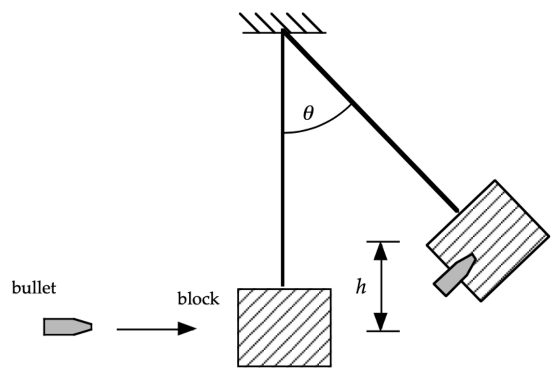
   $F_{net} = 13000N$

4. Calculate the impulse on the bullet from the gun, magnitude and direction.

$J = F_{avg}\Delta t$
$J = (+13000N)(0.0040s) = 52N \cdot s$

$J = \Delta p$
$J = m(v_f - v_i)$
$J = (0.130kg)(400m/s - 0) = 52kg \cdot m/s$

FRQ #2



A ballistic pendulum is used to measure the speed of a projectile: a 5.0 gram bullet is fired into a 1.0 kg block of wood. The bullet sticks into the wood, and the bullet-block swings up to a height of 5.0 cm.

1. Find the initial speed of the projectile just before it hits the block.
   a. A pendulum swinging up is a conservation of energy problem, and I have enough information to be able to solve that. So I'll do that first, and then work my way backwards from there.
      $K_{initial} = U_{final}$
      $\frac{1}{2}m_{bull+bl}v'^2 = m_{bull+bl}gh$
   b. $v' = \sqrt{2gh}$
   c. This "initial velocity" for the energy part of the problem is the same as the "final velocity" from the collision part of the problem. So:

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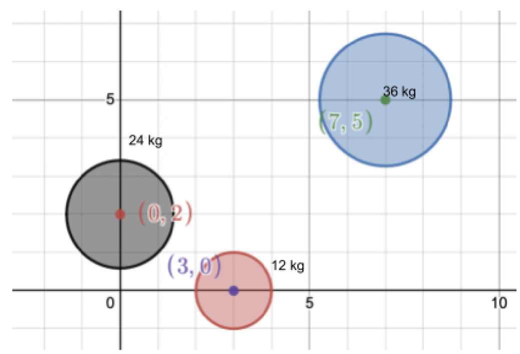
$$m_{bull}v_{bull} + 0 = (m_{bull} + m_{bl})v'$$
$$v' = \sqrt{2gh}$$
$$m_{bull}v_{bull} = (m_{bull} + m_{bl})\sqrt{2gh}$$
$$v_{bull} = \frac{(m_{bull} + m_{bl})\sqrt{2gh}}{m_{bull}}$$
$$v_{bull} = \frac{(0.005 + 1.00)\sqrt{2(9.8)(0.05)}}{0.005}$$
$$v_{bull} = 199m/s$$

2. Find the energy lost in the collision between the block and the projectile.
    a. We now know the masses and velocities of the bullet and block both before and after the collision, so we should be able to use those with a conservation of energy equation to figure out what the ΔEint was.

$$K_{i,bull} + K_{i,bl} = K_{f,bull+bl} + \Delta E_{int}$$
$$\frac{1}{2}mv_{i,bull}^2 + 0 = \frac{1}{2}(m_{bull} + m_{bl})v_f^2 + \Delta E_{int}$$
$$\Delta E_{int} = \frac{1}{2}mv_{i,bull}^2 - \frac{1}{2}(m_{bull} + m_{bl})v_f^2$$
$$\Delta E_{int} = \frac{1}{2}(0.005)(199)^2 - \frac{1}{2}(1.005)(0.99)^2$$
$$\Delta E_{int} = 98.5J$$



FRQ #3

Calculate Xcm and Ycm for the system to the right

$$Xcm = \frac{m1x1 + m2x2 + m3x3}{(m1 + m2 + m3)}$$
$$= \frac{12(3) + 24(0) + 36(7)}{12 + 24 + 36}$$
$$Xcm = 4$$

$$Ycm = \frac{m1y1 + m2y2 + m3y3}{m1 + m2 + m3}$$
$$= \frac{12(0) + 24(2) + 36(5)}{12 + 24 + 36}$$
$$Ycm = 3.17$$