Term Name

Class Name

Yun Zhang College Physics 1 Problems - Momentum and Collisions

Name: ____________________

Date: ____________________

Section: ____________________

Question 1 **(1 point)**

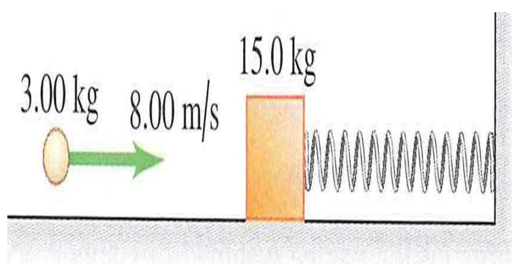
Elastic Collision

A 120 kg ice hockey goalie, originally at rest, catches a 0.150 kg hockey puck slapped at him at a velocity of 35.5 m/s. Suppose the goalie and the ice puck have an **elastic** collision and the puck is reflected back in the direction from which it came. **Take the puck's initial moving direction as positive.**

(a) What is the puck's final velocity (in m/s)? (keep 2 decimal places)
(b) What is the goalie's final velocity (in m/s)?   (keep 3 decimal places)

(c) To verify this is indeed an **ELATIC** collision,
Calculate the total kinetic energy of puck + goalie **before** the collision. (keep 2 decimal places)
Calculate the total kinetic energy of puck + goalie **after** the collision. (keep 2 decimal places)

Question 2 **(1 point)**



Integrated: Collision, Spring + block

A 15.0 kg block is attached to a horizontal spring with a spring constant of 480.00 N/m, and is resting on a frictionless horizontal table. Suddenly it is struck by a 3.0 kg stone traveling horizontally at 8.0 m/s to the right. After the sollison the stone rebounds at 1.80 m/s to the left.

(a)   Find the speed (in m/s) of the block right after the collision.

(b) After the collision, find the maximum compression (in meters) of the spring (when the block comes to a momentary stop).
Think: What physics law to apply for this problem? Review on previous spring + block problems.

Question 3 **(1 point)**

Football Player Catches a Ball

Professional Application. A 100 kg football player catches a 0.750 kg ball with his feet off the ground with both of them moving horizontally. The player's speed is 6.25 m/s, and the ball's speed is 28.6 m/s.

(a) First, consider the situation where the player and the ball are going in the **same direction**, and take this direction as positive. Calculate their final velocity (in m/s).
(b) Calculate the change in the kinetic energy (in Joules) of the system (of the player and the ball). ΔKE = KE(system,f) - KE(system,i).
(c) Now consider the situation where the player and the ball are inititally going in the **opposite directions**. Take the **player's initial moving direction** to be **positive**. Calculate their final velocity (in m/s).
(d) Calculate the change in the kinetic energy (in Joules) of the system (of the player and the ball). ΔKE = KE(system,f) - KE(system,i).

Question 4 **(1 point)**

What is the mass of a large ship that has a momentum of 1.55x10^9 kg•m/s , when the ship is moving at a speed of 1,165 km/h?

Question 5 **(1 point)**

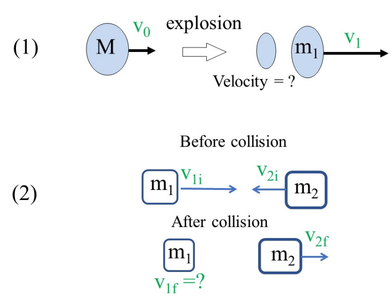
A bullet is accelerated down the barrel of a gun by hot gases produced in the combustion of gun powder. What is the average force exerted on a 0.0414 kg bullet to accelerate it to a speed of 720 m/s in a time of 4.50 ms (milliseconds)?

Question 6 **(1 point)**

Conservation of Total Momentum of a system

Don't use scientif notation in all answers.

(a) A 10-kg cannon-ball is inserted into a 160 kg cannon (the mass of 160 kg is for the cannon itself) at rest. When the cannon-ball is fired, the cannon recoils at a speed of 9 m/s.
What is the **speed** (in m/s) of the **Cannon-ball** right after it leaves the cannon?



(b) In FIgure (1), In midair an M = 150 kg bomb explodes into two pieces of m1 = 120 kg and another, respectively. Before the explosion, the bomb was moving at 25.0 m/s to the east. After the explosion, the velocity of the m1 = 120 kg piece is 62.0 m/s to the east. Find the velocity (in m/s) (with a proper sign) of the other piece after the explosion.

(c) In Figure (2) An m_1=2.3 kg cart moving to the right with a speed of 1.60 m/s has a head-on collision with an m_2= 6.0 kg cart that is initially moving to the left with a speed of 1.40 m/s. After the collision, the m_2 =6.0 kg cart is moving to the right with a speed of 0.7 m/s.

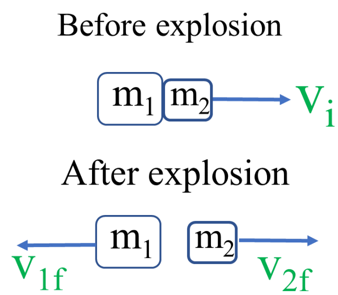
What is the final velocity (in m/s) (including a proper sign) of m_1?

If the duration of the collision in Figure (2) is 0.06s, find the magnitude of the average force (in Newtons) exerted on the m_2 = 6.0 kg cart during the collision.

Question 7 (1 point)

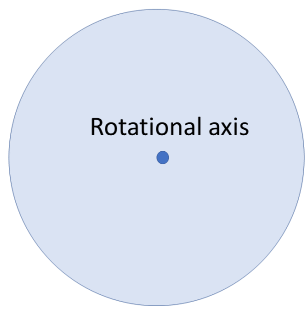
Problem 3 Momentum and Rotation

3A.



As shown in the above figure, both parts of a composite object are initially moving to the right at a certain speed Vi. Suddenly an explosive between the two parts detonates. After the explosion the **m1**=4.9 kg part moves to the **left** at a speed of **v1f =** 0.60 m/s, and the **m2** = 2.0 kg part moves to the **right** at a speed o**f v2f =** 2.20 m/s.
Take **the right** as positive direction. Find the initial velocity Vi of the two parts together.
Keep 3 decimal places.

3B.



A round solid disk rotates counterclockwisely about its center. Its initial angular velocity is 17.80 rad/s. The disk slows down to a final angular velocity of 5.20 rad/s in 3.30 s.
Keep 3 decimal places in all answers except otherwise specified

(a) Find the angular acceleration with a proper sign.

The disk has a mass of 2.00 kg and a radius of R =0.45 m. Its moment of inertia is $\frac{1}{2}mR^2$. (b) Find the net torque (with a proper sign) exerted on the disk in the slowing down process. .
(c) What is the angular displacement in radian during this slowing down process?
(d) While the disk rotates at 5.20 rad/s, what is the linear (tangential) speed (in m/s) of a point on the edge of the disk? The disk's radius is 0.45 m.
(e) While the disk rotates at 5.20 rad/s, what is its **rotational** kinetic energy?
(f) While the disk rotates at 5.20 rad/s, its center is let go, and the disk rolls without slipping on a horizontal surface. What is its **Translational** kinetic energy?

Check that your score for this problem is shown in Canvas Gradebook.

If it doesn't, make sure every part has been completed.

If your score shows up in Canvas, DON"T submit screenshot (but you can keep the screenshot as a safe measure.)

In case the score doesn't show up in Canvas, I will NOT be able to see your work. To resolve dispute**, submit** screen shot which must include:
(1) **The Score and header** of this problem
(2) Your name (in case you are using family members' computer account, put a note when you submit the screenshot).
(3) Time stamp

Though Varafy doesn't show your name, you can use other ways to have your name (or family members' account name) shown on your computer screen.

Question 8 **(1 point)**

Conservation of Total Momentum of a System (Stick together)

(a) Professional Application. Suppose two loaded train cars are moving toward one another, the first having a mass of 1050 kg and a velocity of 0.300 m/s, and the second having a mass of 1100 kg and a velocity of -0.120m/s. (The minus indicates direction of motion.) The two train cars are coupled together by being bumped into one another. What is their final velocity (in m/s)?

(b) Suppose a clay model of a koala bear has a mass of 0.28 kg and slides on ice at a speed of 0.450 m/s*. It runs into another clay model, which is initially motionless and has a mass of 0.350 kg. Both being soft clay, they naturally stick together. What is their final velocity (in m/s)?*

(c) A 920 kg *car initially moving at* 29.0 m/s *hits a 150-kg deer initially running at 12.0 m/s in the same direction. After the hitting. the deer remains on the car. What is the final velocity (in m/s)?*

Question 9 **(1 point)**

These problems involve **Impulse-Mometum theorem, and the Work-Kinetic Energy theorem.** Both theorems are combinations of **Newton's** S**econd Law and 1D kinmatics.**

DON"T use scientific notation in all answers.

(a) A runaway train car that has a mass of 14000 kg travels at a speed of 9.5 m/s down a track. Compute the time (in seconds) required for a force of 1200 N to bring the car to rest.

(b) A bullet is accelerated (from rest) down the barrel of a gun by hot gases produced in the combustion of gun powder. If the average force exerted on a 0.015 kg bullet to accelerate it is 3400 N, what will be the bullet's speed (in m/s) in a time of 0.002 s?

(c) Professional Application. A car moving at 12.9 m/s crashes into a tree and stops in 0.43 s. Calculate the magnitude of the force (in Newtons) the seat belt exerts on a passenger in the car to bring him to a halt. The mass of the passenger is 70 kg.

Compare and contrast question (d) to Question (c):
(d) A 73 kg person is riding in a car moving at 20 m/s when the car runs into a bridge abutment. Calculate the magnitude of the average force (in Newtons) on the person if he is stopped by a padded dashboard that compresses an average distance of 0.28 m
Hint: Question (d) can be solved either by the **work - KE theorem** or the combination of **Newton's** S**econd Law and 1D kinmatics.**
In essence, the work-KE theorem is a combination of Newton's Second Law and 1D kinmatics

The following problem combines questions (c) and (d).
(e) A 0.55 kg hammer is moving horizontally at 7.5 m/s when it strikes a nail and comes to rest after driving the nail 0.01 m into a board.
What is the duration (in seconds) of the impact? Keep 2 Non-zero digits in the decimal. (Hint: use 1D kinematics)

Calculate the magnitude of the average force (in Newtons) on the hammer using the **Impulse-Mometum theorem.**

Calculate the magnitude of the average force (in Newtons) on the hammer using the **work - KE theorem.**

Question 10 **(1 point)**

At what speed would a 3.21x10^4 kg airplane have to fly to have a momentum of 1.45x10^9 kg•m/s (the same as the ship's momentum in the problem above)?

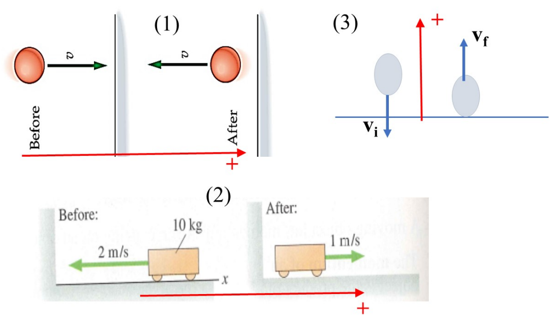
Question 11 **(1 point)**

Rifle and Bullet

A 0.0150 kg bullet is accelerated from rest to a speed of 565 m/s in a 3.75 kg rifle (which is inititally at rest). The pain of the rifle’s kick is much worse if you hold the gun loosely a few centimeters from your shoulder rather than holding it tightly against your shoulder.

(a) Take the **bullet's velocity** as **positive**. Calculate the recoil velocity (in m/s) (with a proper sign) of the rifle if it is held loosely away from the shoulder.
(b) How much kinetic energy (in Joules) does the rifle gain?
(c) What is the recoil velocity (in m/s) if the rifle is held tightly against the shoulder, making the effective mass 28.75 kg?
(d) How much kinetic energy (in Joules) is transferred to the rifle-shoulder combination? The pain is related to the amount of kinetic energy, which is significantly less in this latter situation.

Question 12 **(1 point)**



Impulse - Momentum Theorem

DON"T use scientific notation in all answers.

(1) In figure (1), a child drives a bumper car head on into the side rail, and the wall exerts a force of 3,275 N on the car for 0.40 s.
Take the original direction of the car as positive. What impulse (in N s or kg m/s) is imparted on the car by this force? Pay attention to the direction of the force exerted on the car.
Find the final velocity (in m/s) of the bumper car if its initial velocity was 5.50 m/s and the car plus driver have a mass of 225 kg. You may neglect friction between the car and floor. Pay attention to the direction of the final velocity.

(2) As shown in the figure (2) a 10 kg cart moving to the left at 2 m/s hits a wall and bounces back at 1m/s to the right. If the cart is in contact with the wall for 0.005 s, find the magnitude and the direction of the average force exerted on the **WALL.** **The chosen positive direction is shown in the figure.**

Remember: the magnitude of a vector is always positive.

The mangitude of the average force (in Newtons) is
The direction of the force on the **WALL** is

a. to the left
b. to the right

(3) As shown in the figure (3) a 0.80 kg ball collides with the ground and bounces back. Its velocity right before hitting the ground is downward but unknown. During the collision with the ground that lasts 0.050 s, the ball delivers an average force of 160 N to the ground. The ball bounces upward with a speed of 2.10 m/s. (Since the gravitational force on the ball is much smaller than the collision force, the gravitation force can be neglected.)

The chosen positive direction is shown in the figure.

Find the velocity (in m/s) (including a correct sign) of the ball right before the collision.