Worksheet 4.4 conservation of momentum in 2d answer key

At the end of this section, you'll get: Describe linear momentum conservation laws. Get expressions for momentum conservation. Describe momentum conservation by example. Describe the momentum conservation law as it relates to atomic and subatomic particles. The information presented in this section supports the following AP® learning objectives and science practices: 5.A.2.1 Students are able to determine open and closed systems for daily situations and apply conservation concepts for energy, charges, and linear momentum to those situations. (S.P. 6.4, 7.2) 5.D.1.4 Students can design experimental tests on linear momentum conservation principles, predict experimental outcomes using principles, analyze data generated by experiments whose uncertainty is expressed probable, and evaluate the match between predictions and results. (S.P. 4.2, 5.1, 5.3, 6.4) 5.D.2.1 Students can predict qualitatively, in terms of linear momentum and kinetic energy, how the outcome of a collision between two object changes depends on whether the collision is elastic or endless. (S.P. 6.4, 7.2) 5.D.2.2 Students are able to plan data collection strategies to test momentum conservation laws in the collision of two elastic or inelastic objects and analyze the resulting data graphically. (S.P.4.1, 4.2, 5.1) 5.D.3.1 Students can predict the system mass center velocity when there is no interaction outside the system but there is no interaction in the system (that is, students only acknowledge that the interaction in the system does not affect the center of mass movement of the system and can determine that there is no external power). (S.P. 6.4) Momentum is an important quantity as it is preserved. Yet it is not preserved in instances in Impulse and Linear Momentum and Force, where major changes in momentum are generated by force acting on the system of interest. Under what circumstances is momentum preserved? The answer to this question involves consideration of a large system. It is always possible to find a larger system where the amount of momentum is constant, although the momentum changes for the components of the system. If a footballer walks into goal in the end zone, there will be a force over him that causes him to bounce backwards. However, the Earth also redeems —conquering the momentum—because of the force used on it through goals. Because the Earth's many orders of magnitude are greater than the players, the recoil is very small and can be ignored in any practical sense, but it is real. Consider what happens if the mass of two colliding objects is more similar than the public of footballers and the Earth—for example, one car that came across another, shown in Figure 8.6. Both cars are dragging in the same direction when the lead car (labeled m2)m2) size 12{mSub { size 8{2} } }}} {} is dissolved by a trailing car (labeled m1).m1). size 12{m rSub { size 8{1} } }\) . } {} The only disbalance force on each car is the force of the collision. (Assume that the effects of friction are ignored.) Car 1 slowed as a result of the collision, losing some momentum, while car 2 accelerated and gained some momentum. We will now show that the amount of momentum the two-car system is still ongoing. Figure 8.6 Mass car m1m1 size 12{m rSub = size 8{1} } }} move with direction size v1v1 12{v rSub = size 8{1} }} into another car mass of m2m2 size 12{m rSub { size 8{2} } } {} and direction v2v2 size 12{v rSub { size 8{2} } }} that it follows. As a result, the first car slows down the speed v'1v'1 size 12{ { {v}} soup { ' } rSub { size 8{1} } {} and second speed up to the size speed v'2v.2 12{ { {v}} soup { } rSub { size 8{2} but the momentum amount ptotptot size 12{p RSub { size 8{tot} }} both cars are the same before and after the collision (if you consider friction to be ignored). Using the definition of intuition, car momentum change 1 is given by Δ p 1 = F 1 Δ t , Δ p 1 = F 1 Δ t , size 12{Δp rSub = size 8{1} } =F rSub size 8{1} } Δt {} 8.32 where the size of F1F1 12{F lSub { size 8{1} }} is the force on the car 1 because of car 2 , and ΔtΔt size 12{Δt} {} is the time of acting (collision period). Intuitively, it seems obvious that the time of the collision is the same for both cars, but it is only true for objects moving at normal speeds. This assumption must be modified for objects moving near the speed of light, without affecting the results of preserved momentum. Similarly, changing car momentum 2 is Δ p 2 = F 2 Δ t, Δ p 2 = F 2 Δ t, size 12{Δp rSub { size 8{1} } =F rSub { size 8{1} } Δt} {} 8.33 where F2F2 is the power on the car 2 because of the car 1, and we assume the collision period ΔtΔt size 12{?t} is the same for both cars. We know from Newton's third law that F2=-F1F2=–Size F1 12{F rSub { size 8{2} } = - FSub { size 8{1} } }, and soΔp2=−F1Δt=−Δp1.Δp2=−F1Δt=−Δp1. size 12{Δp rSub = size 8{2} } = - F rSub { size 8{1} } Δt= - Δp rSub = size 8{1} } }}}8.34 Therefore, momentum changes are the same and contrary, and Δp1+Δp2=0.Δp1+Δp2=0. size 12{Δp rSub { size 8{1} } +Δp rSub { size 8{2} } =0} {}8.35 Because the momentum change adds to zero, the total momentum of the two-car system is continuous. That is, p1+p2= constant,p1+p2= continuous, size 12{p RSub { size 8{1} } +p{2}s 2,p1+p2=ps 1+ps = constant { }8.36 p1+p2=ps 1+ps 2,p1+p2=ps 1+ps 2, size 12{pSub { size 8{1} +pSub = + rSub = } = { {p}} sup { { = rSub { size 8{1} } + {p}} soup { ' ' use 8{2} } } {}8.37 where p'1ps 1 size 12{ {p}} soup { ' } rSub { size 8{1} } }} and p'2p'2 size 12{ {p}} soup { ' } rSub { size 8{2} } }} is the momenta of the car 1 and 2 after the collision. (We often use the premier to mark the final state.) This decision—the momentum is preserved—has the authenticity far beyond the previous one-dimensional case. It can also be shown that the amount of momentum is preserved for any isolated system, with any number of objects inside. In equational form, conservation of momentum principle for isolated system written p tot = constant, p tot = constant, size 12{pSub { size 8{tot} } =constant} {} 8.38 or ptot=ps tot,ptot=pstot, size 12{p rSub { size 8{tot} } } =p' rSub { size 8{tot} } {}8.39 where the size of the ptotptot 12{p rSub { size 8{tot} is the total momentum (total momenta of individual objects in the system) and ps totp'tot size 12{ i.e. p' rSub { size 8{tot} }} is the total momentum some time later. (The amount of momentum can be shown as the momentum of the center of the system mass.) An isolated system is defined as one by which the clean external force is zero Fnet=0.Fnet=0. size 12{ left (F rSub { size 8{ ital net } } =0 right) . — {} p tot = constant p tot = p tot (isolated system) p tot = p constant tot = p tot (isolated system) Isolated system is defined as one by which the external power of the net is zero Fnet=0.Fnet=0. size 12{ left (F rSub { size 8{ ital net } } =0 right) . } {} Consider two air carts with the same mass (m) on linear tracks. The first cart moves with a v speed towards the second cart, which initially rests. We will take the initial direction of the first cart movement as a positive direction. The momentum of the system will be preserved in the collision. If the collision is elastic, then the first trolley will stop after the collision. Therefore, momentum conservation tells us that the second cart will have the final velocity v after a collision in the same direction as the initial velocity of the first cart. The kinetic energy of the system will be preserved because the public is the same and the final direction of the trolley 2 is equal to the initial direction of the trolley 1. What graph is the amount of momentum vs. time looks like in this case? What graph is the amount of kinetic energy vs. time looks like in this case? Consider the center of the mass of the system as a reference frame. As the 1 trolley approaches the 2th cart, the mass center remains exactly the halfway between the two carts. The mass center moves towards a strange trolley 2 at the speed of v2v2. After the collision, the mass center continued to move in the same direction, away from (now caring) cart 1 at v2v2 speed. How the central-of-mass direction graph is vs. time compared to the momentum graph vs. on the other hand that both carts move with the same speed v in the opposite direction towards the mass center. Again, they had a elastic collision, so after the collision, they exchanged speed (each cart moved in the opposite direction to the initial movement with the same speed). As both trolley approaches, the mass center is precisely between the two carts, at the point where they will clash. In this case, how is the central-of-mass velocity graph vs. time compared to the momentum graph of the system vs time? Let us go back to an example where the first cart moves with v speed towards the second cart, initially resting. S let's say the second cart has a few putty at one end so that, when the collision occurs, the two carts stick together in an inevitable collision. In this case, the conservation of momentum tells us that the final velocity of the two-cart system will be the first half-velocity of the trolley, in the same direction as the initial movement of the first cart. Kinetic energy will not be preserved in this case, however. Compared to the trolley moved before the collision, the mass moved overall after the collision doubled, but the halvages were divided. The initial kinetic energy of the system is: k = 1 2 m v 2 (first cart)+0(2nd cart)= 1 2 m v 2 k i = 1 2 m v 2 (first cart)+0(2th cart)= 1 2 m v 2 Kinetic energy final both carts (2m) moving together (at v/2 speed) are: k = 1 2 (2m) (v 2) 2 = 1 4 m v 2 k = 1 2 (2m) (v 2) 2 = 1 4 m v 2 What is the graph of total momentum vs time looks like in this case? What graph is the amount of kinetic energy vs. time looks like in this case? Consider the mass center of the system. As the 1 trolley approaches the 2th cart, the mass center remains exactly the halfway between the two carts. The mass center moves towards a strange trolley 2 at the speed of v2v2. After the collision, the two carts moved in together at the speed of v2v2. How is the central-of-mass velocity graph vs. time compared to the momentum graph vs time? Let's say that both carts move with the same speed v in the opposite direction towards the mass center. They have put at the end of each cart so they stick together after the collision. As both trolley approaches, the mass center is precisely between the two carts, at the point where they will clash. In this case, how is the central-of-mass velocity graph vs. time compared to the momentum graph of the system vs time? Perhaps the easier way to see that momentum is preserved for isolated systems is to consider Newton's second law in terms of momentum, Fnet=ΔptotΔt Fnet=ΔptotΔt . For isolated systems, Fnet=0Fnet=0; therefore, Δptot=0Δptot=size 12{?p rSub { size 8{tot} } }=0} {}, and ptotptot is We have stated that three long dimensions in nature—size xx 12{x} {}, size yy 12{y} {}, and zz size 12{z} {}—are free, and they are free, and they are to note that momentum can be preserved in different ways along each dimension. For example, during projectile motion and where air resistance is ignored, momentum is preserved in the upward direction because the cruising force is zero and the momentum has not changed. But along the vertical direction, the net vertical force is not zero and the projectile momentum is not preserved. (See Figure 8.7.) However, if the momentum of the projectile-Earth system is considered towards vertical, we find that the amount of momentum is preserved. Figure 8.7 The outpouring component of the projectile momentum is preserved if air resistance is ignored, even in this case where the space investigation separates. The forces that cause separation are internal to the system, so that the external power of the net congestion of the Fx-netFx-net is still zero. Vertical components of momentum are not preserved, since the vertical force of the Fy-netFy-net net is not zero. In the vertical direction, the probe-Earth system of space needs to be considered and we find that the amount of momentum is preserved. The mass center of the space investigation takes the same path it would be if separation did not occur. Conservation of momentum principles can be used for different systems as an interesting coma of Earth and gas containing a large number of atoms and molecules. Momentum conservation is violated only when the outer power of the net is not zero. But another larger system can always be considered where momentum is preserved by only including external power sources. For example, in a two-car collision considered above, the two-car system conserved the momentum while each one system one car did not. Hold the tennis ball side by side and come into contact with basketball. Drop the ball together. (Be careful!) what happened? Describe your observations. Now hold the tennis ball on top and come into contact with basketball. what happened? Describe your observations. What do you think will happen if basketball is held on top and in contact with tennis balls? Tie two tennis balls alongside a string of about feet long. Hold one ball and let the other hang and throw in the ballistic trajectory. Describe your observations. Now mark the center of the string with a bright ink or attach a brightly coloured sticker to it and throw it away again. what happened? Describe your observations. Some aquatic animals such as jelly are moving based on momentum conservation principles. Jelly fills its umbrella with water and then pushes the water out causing movement in the opposite direction to the water jet. Squids push themselves in the same way but, in contrast to jelly, are able to control the direction in which they move by targeting their nozzles forward or backward. Typical squids can move at speeds of 8 to 12 is a diagnostic tool used in the second half of the 20th century to study heart strength. About once per second, your heart is tubling, swallowing blood into the aorta. The force in the opposite direction is deployed across your entire body (remember Newton's third law). Ballistocardiograph is a device that can measure this response force. This measurement is done by using the sensor (resting on the person) or by using a moving table suspended from the ceiling. This technique can gather information about the strength of the heartbeat and blood isipas passing from the heart. However, electrocardiograms (ECG or EKG) and echocardiograms (ECHO or ECHO heart; techniques that use ultrasounds to see heart image) are more used in cardiological practice. Experimental design to confirm the conservation of linear momentum in a one-dimensional collision, both elastic and inelastic. For simplicity, try sure the friction is minimized so that it has a ignored effect on your experiments. As you consider your experiment, consider the following questions: Predict how the end momentum of the system will be compared to the initial momentum of the system that you will measure. Justify your predictions. How would you measure the momentum of each object? Should you have two objects in motion or one object bouncing off the hardcore surface? Should you confirm the relationship mathematically or graphically? How do you estimate the uncertainty of your measurements? How will you express this uncertainty in your data? When you have completed each experiment, compare your predictive results about the early and final momentum of the system and evaluate your results. Momentum conservation is quite useful in describing the collision. Momentum is important for our understanding of atomic and subatomic particles because many of what we know about these particles come from collision experiments. Conservation of momentum principles not only applies to macrosconic objects, it is also important for the exploration of our atomic and subatomic particles. The giant machines hurl subatomic particles to each other, and researchers assessed the results by assuming momentum conservation (among others). On a small scale, we find that their particles and properties are invisible to the naked eye but can be measured with our instruments, and that these subatomic particle models can be built to describe results. Momentum was found to be the property of all subatomic particles including particles that did not massacred such as light composing photos. Momentum becomes an indicative particle property that momentum may have an identity beyond the mass description of the object multiplied by the velocity of the object. Indeed, momentum is related to the nature of the waves and plays a fundamental role what size is taken and how do we take this size. This. we find that the conservation of momentum principles is valid when considering the particle system. We use this principle to analyze the public and other undetectable particles before, such as atomic nucleus and the existence of quarters that make up nuclei particles. Figure 8.8 below describes how particles are scattered backwards from others implying that the target is massive and compact. The experiment sought evidence that the quartet formed a proton (a type of particle that forms nuclei) scattered high energy electrons from protons (hydrogen atomic nuclei). Electrons sometimes scatter directly backwards in a way that implies very small and highly dense particles forming these proton-observations are considered almost directly evidence of the quartet. This analysis is based in part on the conservation of the same momentum principle that works well on a large scale. Figure 8.8 Subatomic particles are scattered directly backwards from the target particles. In an experiment seeking evidence for quartet, electrons are observed to sometimes scatter straight backwards from a proton. Proton.

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